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Sulfuric Acid Plant Installation and Operating Costs, Phelps Dodge Corporation, Douglas, Arizona

PEDCo-Environmental Specialists, Inc, Cincinnati, Ohio

Prepared for

Environmental Protection Agency, San Francisco, Calif Region IX

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SULFURIC ACID PLANT

INSTALLATION AND OPERATING COSTS

PHELPS DODGE CORPORATION

DOUGLAS, ARIZONA

Report Number: EPA 909/9 76 006

Prepared by

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EPA Project Officer: William Rogers Oliver

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16. ABSTRACT

This report discusses installation and operation costs for a double contact sulfuric acid plant to be installed at the Phelps Dodge Corporation copper smelter in Douglas, Arizona. Equipment necessary for the operation of the acid plant is discussed, including: converter uptake and hood system, gas cooling system, ductwork, double contact acid plant (1323 ton per day at 4.5 percent SO_2), modification of reverberatory furnace fugitive gas ductwork, acid neutralization facilities, and other equipment such as tracks, new wells, and water treatment facilities. Capital costs amount to $62.9 million and annual operating costs amount to $21 million before credit for any product acid. Installation is technically feasible and would not involve any innovative technology while significantly reducing sulfur dioxide emissions.

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SUMMARY

This report contains information on the capital and operating costs that would be incurred if a double contact sulfuric acid plant were installed at the Phelps Dodge Corporation copper smelter in Douglas, Arizona, to control sulfur dioxide emissions from the converter operation. The installation of such a plant would reduce overall plant SO_2 emissions by approximately 40 percent from their current average level of 1100 tons per day.

Installation of a new double contact sulfuric acid plant at the smelter is technically feasible and would not involve any innovative technology. Phelps Dodge currently owns the site on which the acid plant would be built. Water supply is a potential problem, since an average of approximately 1000 gallons per minute would be used in acid production. In addition, the sale of the product acid must be carefully evaluated.

The total costs (escalated to project completion date) include the acid plant itself, converter hood modifications, gas cooling equipment, connecting ductwork, acid storage and transportation facilities, and required ancillary equipment. Costs for a long-term acid disposal pond also are presented.

Costs in this report represent only those required for installation and operation of the SO_2 control system. Costs for modifications to make the smelter run more efficiently are not included, since they are not essential to control SO_2.

A cost breakdown of the components required for SO_2 control of the converter off-gases is presented in the following tabulation.

System	Total installed cost, $10^6	Annual cost, $10^6
Hood modifications	1.02	0.30
Converter gas cooling system	0.99	0.47
Ductwork	0.70	0.15
Double contact acid plant	50.5	14.6
Acid storage and transportation facilities	3.23	1.47
Short-term acid disposal facilities	4.82	3.40
Rerouting of reverberatory fugitive emissions	1.11	0.30
Other support facilities	0.50	0.12
Total	$62.87	$20.81

As shown, a total of approximately $63 million would be required over a three-year period to complete this installation. The annual operating costs, including interest and amortization of the capital costs, amount to about $21 million per year before credit for acid received. A credit of $10 million could be realized for sulfuric acid, thus

reducing the annual cost to $11 million or about 4 cents per pound of copper. If sulfuric acid cannot be marketed, an acid disposal facility consisting of a neutralization process and a lined pond would be required. This facility would cost approximately $21 million, and add $6.6 million to the annual cost.

1.0 INTRODUCTION

The Phelps Dodge Corporation operates an integrated primary copper smelter complex at Douglas, Arizona. Currently operating under a supplementary control system to reduce ambient concentrations of sulfur dioxide (SO_2), this smelter processes an average of 1512 tons of concentrate per day, yielding 378 tons of copper product and emitting approximately 1100 tons of SO_2.[1]

Off-gases from the roasters and reverberatory furnaces are vented through electrostatic precipitators to remove particulate matter; the precipitators are vented through a 544-foot stack. Off-gases from the converters also are vented through precipitators, then through a 561-foot stack.[2] The plant has no equipment for control of SO_2 emissions.

On October 22, 1975, EPA proposed regulations pertaining to the allowable emissions of SO_2 from designated primary copper smelters in Arizona. These regulations require the installation of a double contact sulfuric acid plant to control emissions of SO_2 from the Phelps Dodge smelter at Douglas. This study is concerned with the costs of installing such a plant at the Douglas facilities. The sulfuric acid plant would considerably reduce SO_2 emissions from the

converters, which currently account for about 40 percent of the plant's overall SO_2 output.

The smelter consists basically of concentrate-handling facilities, 24 multiple-hearth roasters (18 in operation at one time), 3 reverberatory furnaces, 5 Peirce-Smith converters (3 or occasionally 4 in operation at one time), 2 anode furnaces, and associated support equipment. This report describes the various items that must be installed or modified for production of sulfuric acid from the converter off-gas. It does not consider other plant modifications that would improve overall smelter operation and efficiency but that are not directly required for control of SO_2.

Following are the major items considered in the cost analysis:

1. Converter off-gas uptake and hood system.
2. Off-gas cooling system.
3. Ductwork and valves to convey the off-gases to the acid plant.
4. Double contact acid plant.
5. Modification of reverberatory furnace ductwork for control of fugitive gases.
6. Yard modifications and additions such as tracks, roads, gas lines, electrical switchgear, wells, and water treatment facilities.

Section 2 describes the cost estimating procedures, and Section 3 presents the detailed cost projections in terms of the major components and facilities required.

CHAPTER 1 REFERENCES

1. Correspondence from M.P. Scanlon, Phelps Dodge Corporation to William Oliver. EPA, Region IX. June 17, 1976.

2. Weisenberg, I.J., and J.C. Serne. Design and Operating Parameters for Emission Control Studies: Phelps Dodge, Douglas Copper Smelter. EPA Publication EPA-600/2-76-036h. February 1976. pg. 5 and 6.

2.0 COST ESTIMATING PROCEDURES

PEDCo obtained information pertaining to process throughput and flows from Phelps Dodge personnel during visits to the Douglas, Arizona Plant and to offices of Stearns-Roger, Inc. in Denver, Colorado. Estimation of the total installed direct costs entails specifying and sizing the required equipment, obtaining current (1976) costs for major components from equipment suppliers, estimating ancillary equipment costs,[1,2] and estimating installation charges based on labor requirements. No specific retrofit factor is applied, since difficulties of installing equipment into an existing plant are accounted for in the labor estimates. Commonly accepted engineering estimating factors are used to calculate indirect costs.[3] A contingency factor (usually 5 percent) to allow for omissions, price fluctuations, field changes, unforeseen installation problems, etc. is applied to the total installation cost (direct and indirect). An average escalation factor of 7.5 percent per year is also applied to the total installed cost to account for increases in the cost of equipment and labor before and during construction. The estimates do not include costs for additional land or any interruptions in production.

Indirect capital costs as used in this study are itemized in each cost area summary, as follows:

Engineering costs, including both owner and contractor administrative, process, project, and general engineering; design and related functions for specifications; bid analysis; cost analysis; accounting; reports; consultant fees; purchasing; procurement; travel expenses; living expenses; expediting; inspection; communications; training of plant personnel; field engineering and safety engineering. Estimated at 1.5 to 20 percent of total direct cost, depending on complexity of the system design.

Contractor's fee and expenses, including costs for field labor and overhead; supervision; field office; personnel; construction offices; temporary roadways and railroad tracks; maintenance and weld shops; parking lots; communications; temporary piping and electrical and sanitary facilities; safety security of all types--fire, material, medical, etc; construction tools and rental equipment; unloading and storage of materials; travel expenses; insurance; overhead; field testing of equipment; labor relations; permits, licenses, taxes, legal expenses, and profit. Estimated at 3 to 20 percent of total direct costs, depending on complexity of equipment and installed cost.

Interest accrued on borrowed capital during construction estimated at 9 percent of the total direct cost times one-half of the construction period, with progressive payments made during that period.

Freight, including delivery costs on process and related equipment shipped F.O.B. Estimated at 2 to 6 percent of material costs, depending on origin of material.

Off-site expenditures, including service facilities added to the existing plant facilities such as water and electrical lines. Estimated at 1 to 4 percent of total direct cost.

Taxes, including sales tax at 4 percent of material cost.

Shakedown, including equipment malfunctions; alterations to design; premium time for repairs; start-up utilities. Estimated at 0.3 to 5 percent of total direct cost depending on complexity of process.

Spares, (stock to permit a high percentage of process availability), including pumps, valves, controls, special piping and fittings, instruments, spray nozzles, and similar items. Estimated at approximately 0.5 to 6.5 percent of material costs.

The factors used in specific estimates are varied depending on the type and complexity of the system. Indirect costs thus amount to approximately 35 to 45 percent of the total direct cost (material and labor); these also depend on the complexity of the system for which the estimate is made.

Annualized costs include both operating costs (1976 basis) and fixed capital charges, consisting of the following items:

Utilities[4] - electricity at 30.5 mills/kWh, water at $0.1257 per 1000 gallons, fuel oil at $2.80 per 10^6 Btu, and raw materials as required.

Operating labor, consisting of direct labor at $7.066/hr[5] plus supervision estimated at 15 percent of direct labor.

Maintenance, consisting of labor and materials at 0.5 to 8 percent of total installed cost, and common supplies at 15 percent of maintenance labor and materials. Variations in maintenance requirements are due to severity of operating conditions and complexity of the equipment involved in a particular cost area estimate.

Plant overhead and fringe benefits, at 50 percent of operating labor and maintenance, and payroll overhead at 20 percent of operating labor.

Total fixed costs, amounting to 20.32 percent of total installed costs and consisting of straight-line depreciation over 15 years at 6.67 percent (unless otherwise indicated), interim replacement at 0.35 percent, property insurance at 0.3 percent, property taxes at 4 percent,[a] and interest on borrowed capital at 9 percent.

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[a] Current tax rate is $9.80 per $100 assessed value with assessments based on 27 percent of cash value (2.646%); an increase in tax rate is expected.

CHAPTER 2 REFERENCES

1. Godfrey, R.S., Building Construction Cost Data 1976. Duxbury, Robert Snow Means Company, Inc., 1975.

2. Manual published by Richardson Engineering Services, Inc., 10021 Tecum, Post Office Box 726, Downey, California, 90241. 1974.

3. Peters, M.S., and K.D. Timmerhaus, Plant Design and Economics for Chemical Engineers. McGraw-Hill Book Co. New York, New York, 2nd Edition. 1968. Chapter 4.

4. Information provided by Phelps Dodge Corporation personnel at meeting on June 15, 1976.

5. Correspondence: M.P. Scanlon, Phelps Dodge Corporation, to William Oliver, EPA Region IX, June 17, 1976.

3.0 CONTROL COSTS

Costs are presented for the complete converter SO_2 control system including the following components:

- Converter hood system.
- Converter gas ducting and cooling system.
- Ductwork and valving for connection to the acid plant.
- Double contact acid plant, including gas conditioning, converters, absorbers, heat exchangers, etc.; yard modifications, including tracks, roads, and storage; and emergency acid disposal pond.
- Ducting for control of fugitive emissions from the reverberatory furnace.
- Miscellaneous auxiliary equipment, such as oil storage tanks, wells, switchgear, and wastewater treatment facilities.

Equipment for operation of a long-term acid neutralization facility is also evaluated.

From among various available options for installation of an acid plant, we have selected a scheme that would provide satisfactory service for many years and yet would minimize plant modifications and costs. It includes only those changes in ductwork, buildings, hoods, etc. that are required for installation of an acid plant. Other changes that would improve plant operation and efficiency or would upgrade the facilities are not included, since these are not directly applicable to SO_2 control. If Phelps Dodge were to undertake a major construction program at this smelter, other work of this nature might be recommended. Such work is not, however, included in this study.

3.1 CONVERTER HOODS AND UPTAKES

Because the converter hoods do not fit tightly around the converter mouths at this facility, excessive dilution air is now entering the duct system. Figure 3-1 shows the converter aisle with four converters and the overhead crane; the gap between the converter mouth and hood uptake is evident. Room air entering through this gap dilutes the off-gas by about 9 to 1 (air to gas) and reduces the average concentration of SO_2 in the off-gas to about 2 percent by volume. This air also reduces temperature of the gas stream to about 600°F.

Figure 3-1. Converter aisle and hoods.

To facilitate control of SO_2 emissions with a sulfuric acid plant, a higher SO_2 concentration in the off-gas, approximately 4.5 percent, is desirable. An acid plant can handle lower SO_2 concentrations, but costs would increase sharply because of the requirement for gas preheating facilities to maintain autothermal operations. To achieve higher SO_2 concentrations, dilution with room air must be decreased by use of hoods that fit closely around the converter mouth. The lessened dilution will also aid in maintaining higher gas temperatures. Decreasing the dilution to the point that only one volume of room air enters the hood for each volume of off-gas (1:1 ratio) would provide a total gas volume per converter of approximately 44,000 standard cubic feet per minute (scfm), a temperature of about 1,400°F, and a minimum SO_2 concentration of about 4.5 percent. These specifications are used in this study.

The primary problem with decreasing the infiltration of room air is the resultant higher temperatures within the duct, possibly causing greater stress on materials and accelerated buildup of deposits on the interior walls. To reduce this problem, the first 15 feet of the existing hoods would be replaced with new water-cooled sections, as shown in Figure 3-2.

Water-cooled hoods are currently used in ferrous and nonferrous smelting operations, effectively minimizing the

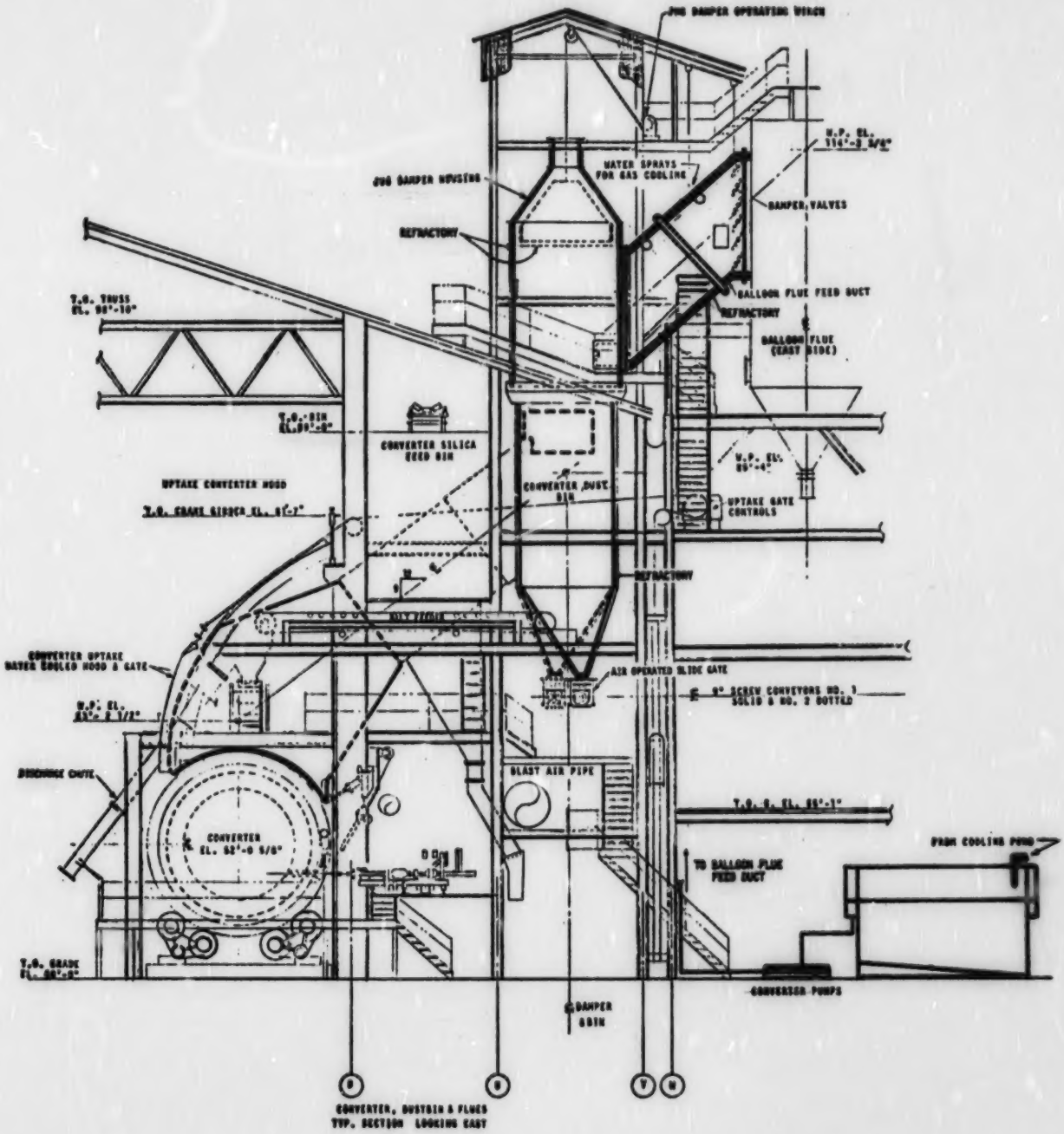


Figure 3-2. Converter hood system.

problem of buildup of materials emitted from the converter mouth. Figure 3-3 shows an example of buildup on the gate that slides down to cover the converter opening.

Figure 3-3. Buildup of deposits on existing converter hood gate.

The converter uptake currently makes an angle of 36.9 degrees with respect to the horizontal in order to clear the low crane rails. According to Phelps Dodge personnel, this causes heavy buildup of deposits on the upper portion of the hood. They maintain that the hood should be inclined more to the vertical to minimize deposits. Such a modification,

however, would require that the crane rails be raised about 15 feet, entailing additional structural support and a higher roof, at a cost of about $15 million.[1] We believe that a water-cooled hood of the present hood configuration could be used with no increase in deposit buildup and with some reduction. A more vertical hood would probably reduce buildup still further, but this modification is not required for SO_2 control. A water-cooled hood system at the Magma smelter in San Manuel, Arizona, similar to the proposed design, has a take-off angle of 37 degrees. This hood system works well, with no buildup problems.[2]

The water flow to the proposed hoods would range from 400 to 550 gallons per minute (gpm), depending on the number of converters in operation. The system would operate in a closed-loop mode, utilizing a 1-hour holding tank with recirculated water from a cooling tower. Two water pumps would be installed per hood, one in operation and one on standby. Water passing through the hood system would be discharged to a tank, then pumped to a cooling tower. The cooled water would then be pumped back to the holding tank and to the hoods. An estimated 10 percent water make-up would be required to compensate for losses by leakage, evaporation, and blowdown.

Table 3-1 presents a breakdown of the total cost of installing such a system on the five converters. The custom-fabricated equipment is the most expensive single item, with total installed costs amounting to $1,020,000. Direct operating costs are about $94,000 per year, but when fixed costs are included the annual costs total $301,000, as shown in Table 3-2.

3.2 CONVERTER GAS DUCTING AND COOLING SYSTEM

The gases leave the hood system at a temperature of 1100 to 1200°F. They must be cooled to about 600°F to prevent damage to the ducts and electrostatic precipitators.

Among the options for gas cooling are a water-spray system, a waste heat boiler, an air-to-gas heat exchanger, and installation of long duct runs to allow for radiation cooling. After consideration of space limitations, steam requirements, and costs, water-spray cooling was selected. A waste heat boiler would cost approximately $890,000 (equipment only),[3] and would be difficult to fit into the existing ductwork. In addition, use of the steam from such a boiler would be limited because of poor quality and variable quantity.[4] An air-to-gas heat exchanger, in which ambient air is heated indirectly by the vent gases, would be large and also would be subject to considerable fouling. Long duct runs are impractical in view of the existing duct configurations and space limitations; this option would

Table 3-1. CONVERTER WATER-COOLED HOOD SYSTEM CAPITAL COSTS

Direct Costs	Material	Labor
Equipment	$414,000	$ 94,000
Instrumentation	3,000	4,000
Piping	67,000	37,000
Electrical	6,000	9,000
Foundations	9,000	34,000
Structural	12,000	3,000
Sitework	1,000	4,000
Insulation	negl.[a]	negl.
Painting	negl.	negl.
Subtotal	$512,000	$185,000
Total direct cost (TDC)		$697,000

Indirect Costs		
Contractor's fee and expenses @ 10% of TDC	$ 70,000	
Engineering @ 6.5% of TDC	45,000	
Interest during construction @ 9% of TDC for 6 mos.	31,000	
Freight @ 2.5% of material	12,000	
Off-sites @ 1.5% of TDC	10,000	
Taxes @ 4% of material	20,000	
Allowance for shakedown @ 2.4% of TDC	17,000	
Spares @ 1% of material	5,000	
Total indirect costs	$210,000	
Total Cost		$ 907,000
Contingency @ 5% and escalation @.7.5% of total cost		113,000
Total installed cost		$1,020,000

[a] negl. - negligible if less than $1000.

Table 3-2. ANNUAL OPERATING COSTS FOR WATER-COOLED HOODS

Cost Component			Annual cost, $
Utilities			
Water	165 gpm[a] x $0.1257/1000 gal.		$ 11,000
Electricity	170 hp ≈ 127 kWh @ 30.5 mills/kWh		33,000
Operating Labor			
Direct	3 hr/day @ $7.066/hr		8,000
Supervision	@ 15% of labor		1,000
Maintenance			
Labor and materials	@ 2% of total installed cost		20,000
Supplies	@ 15% of labor and materials		3,000
Overhead			
Plant	@ 50% of operation and maintenance		16,000
Payroll	@ 20% of operating labor		2,000
Fixed Costs			
Depreciation		6.67%	
Interim replacement		0.35%	
Insurance		0.30%	
Taxes		4.00%	
Interest		9.00%	
Σ = 20.32% of total installed cost			$ 207,000
Total annual cost			$ 301,000

[a] 55 gpm (10% make-up water) for 3 hoods = 165 gpm

entail a great deal of large ducting and structural support.

For protection against high temperatures, the existing balloon flue feed ductwork, the jug damper, and the dust bin collector would be equipped with refractory linings. The jug damper also would be covered with a castable refractory and modified to clear the refractory lining.

As shown in Figure 3-2, the water sprays are in a section of high turbulence, which will provide for adequate mixing of the water spray and the hot gas stream. Immediately after the water sprays, the gases enter the balloon flue, where they mix with gases from the other converters. With this high degree of mixing, nonuniform areas of very hot or very cold gases will be minimized, and corrosion due to gases falling below the acid dew point should not occur.

Water sprays are used at a number of copper smelters and also are used widely in ferrous metallurgical operations for cooling furnace off-gases. In a water-spray cooling system at this plant, two banks of water-spray nozzles (one operational and one spare) would be incorporated into the balloon flue feed duct. Each bank would contain four stainless steel spray nozzles, operating at a pressure of approximately 125 psi and delivering a minimum total flow of 18.4 gpm of water when cooling 44,000 scfm of flue gas from 1100°F to 600°F. The cooling system for each converter would be controlled individually and automatically by means of temperature sensors in the downstream duct.

An emergency 24-inch vacuum break valve would be attached to each of the balloon flue feed ducts to permit inflow of ambient air if the flue gas temperature reaches 800°F. This might occur because of a failure in the water-spray system. The opening angle of the valve would be controllable and would permit a metered flow of air to the system without significantly affecting the SO_2 concentration in the gas feed to the acid plant.

For maintenance purposes, each bank of nozzles would be installed and removed through a 10-inch-diameter flanged port in the balloon flue feed duct; another port of the same size in the opposite side would provide for support of the lead end of the bank. A second set of ports, located approximately 5 feet away, would be used for the spare bank of nozzles. If the spare bank is kept in the flue gas stream, a small trickle of water must pass through the nozzles to protect them from heat and dust buildup. Two maintenance manholes, with access walkways in the vicinity of the water sprays, would also be provided in the balloon flue feed duct, one of them located near the segmented damper valve.

Segmented damper valves are located just before the balloon flue in the feed duct from each converter. The primary purpose of these valves is to permit rapid closure of the feed duct when the converter is being charged, tapped, or skimmed, and thus to prevent excessive air flow into the

balloon flue. The water sprays would be turned off automatically during these periods as the temperature decreased. Without such damper valves, the feed stream to the acid plant would become diluted with room air that is drawn into the hood system.

For maintenance on a converter or its hood system, the segmented damper valve and the existing jug damper valve would be closed. Should the spray header require maintenance, the segmented damper valve would be closed and the spray header bank could then be removed and serviced.

In addition, a deflection shield would be installed to prevent entry of water droplets into the dust bin and uptakes.

Water for the spray nozzles would be recirculated from the acid plant's water clarification system. It would be pumped from the clarifier to a storage tank through a single line and pump, with a second line and pump on stand-by. The storage tank, with a working capacity of 9,000 gallons, would measure 15 feet in diameter by 10 feet high, including a 3-foot freeboard. Following are estimated retention times of the water in the storage tank:

No. of converters operating simultaneously	Water storage retention time, hours
3	2.7
2	4.1
1	8.2

Since the water flow through the nozzles would be synchronized with operation of the converter during blows, it is estimated that the total retention time would be increased by at least 20 percent.

Each spray bank would be equipped with its own piping and pump system so that the spare spray bank unit will be quickly activated to continue the gas cooling. Ten pumps (two per converter) would be located adjacent to the storage tank, each with a total dynamic head of 550 feet. The storage tank would be located in the vicinity of the number 3 converter.

Estimated capital costs for the water-spray cooling system, shown in Table 3-3, amount to $988,000. Equipment and engineering costs are the two largest items. Table 3-4 summarizes the annual operating costs, including the labor costs for one full-time worker assigned to ensure proper operation of the water-spray cooling systems. A large allowance for maintenance is also provided. The total annualized costs are $465,000.

Table 3-3. CONVERTER GAS COOLING SYSTEM CAPITAL COSTS

Direct Costs	Material	Labor	
Equipment	$167,000	$ 62,000	
Instrumentation	incl. in equip.		
Piping	42,000	62,000	
Electrical	25,000	33,000	
Foundations	3,000	9,000	
Structural	58,000	46,000	
Sitework	4,000	14,000	
Insulation	66,000	31,000	
Painting	1,000	4,000	
Subtotal	$366,000	$261,000	
Total direct cost (TDC)		$627,000	
Indirect Costs			
Contractor's fee and expenses @ 10% of TDC		$ 63,000	
Engineering @ 17.5% of TDC		110,000	
Interest during construction @ 9% of TDC for 6 mos.		28,000	
Freight @ 2.5% of material		9,000	
Off-sites @ 1.5% of TDC		9,000	
Taxes @ 4% of material		15,000	
Allowance for shakedown @ 1.6% of TDC		10,000	
Spares @ 2% of material		7,000	
Total indirect costs		$251,000	
Total Cost			$878,000
Contingency @ 5% and escalation @ 7.5% of total cost			110,000
Total installed cost			$988,000

[a]negl. - negligible if less than $1000.

Table 3-4. ANNUAL OPERATING COSTS FOR CONVERTER GAS COOLING SYSTEM

Cost Component			Annual cost, $
Utilities			
Water			$ Negl.[a]
Electricity			6,000
Operating Labor			
Direct	1 man/shift @ $7.066/hr		62,000
Supervision	@ 15% of labor		9,000
Maintenance			
Labor and materials	@ 8% of total installed cost		80,000
Supplies	@ 15% of labor and materials		12,000
Overhead			
Plant	@ 50% of operation and maintenance		82,000
Payroll	@ 20% of operating labor		14,000
Fixed Costs			
Depreciation		6.67%	
Interim replacement		0.35%	
Insurance		0.30%	
Taxes		4.00%	
Interest		9.00%	
Σ = 20.32% of total installed cost			200,000
Total annual cost			$ 465,000

[a]Negl. - Negligible if less then $1000.

3.3 ACID PLANT CONNECTING DUCTWORK

New ductwork will be required to connect the acid plant, located southwest of the converter stack, to the existing discharge flue of the converters' electrostatic precipitators.

To maintain the present gas distribution through the electrostatic precipitators (ESP), two 74-inch-diameter ducts, one from the discharge flue of each pair of precipitators, would be used as shown in Figure 3-4. These ducts would join on the southwest side of the stack to become a single 104-inch-diameter duct running south to the acid plant. Joining of the 74-inch-diameter ducts to the ESP discharge flues could be done at the existing flanged connections shown in Figure 3-5.

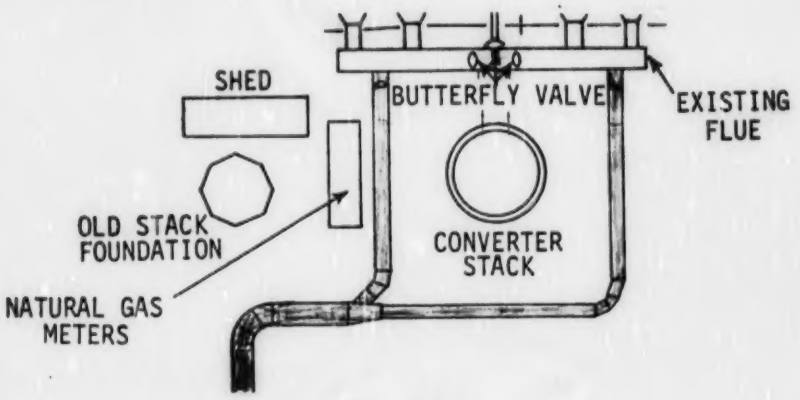


Figure 3-4. Acid plant connecting ductwork.

Figure 3-5. Location of tie-in for acid plant connecting ductwork.

Each of the ducts would be furnished with a 74-inch stainless steel electrically operated butterfly valve to permit gas flow through either duct or, if the acid plant is shut down, directly to the stack through existing ductwork. The valves in the new ducts would be open only when the acid plant is is operation.

The carbon steel ducting would be furnished complete with 2 inches of insulation, a minimum of two expansion joints, and steel A-frame supports from the electrostatic precipitator breechings to the acid plant humidifying tower.

Capital and annualized costs for this ductwork are summarized in Tables 3-5 and 3-6, respectively. Total installed costs are $700,000 (largely ductwork); and annualized costs, which are mainly fixed costs, amount to $150,000.

3.4 SULFURIC ACID PRODUCTION FACILITIES

This section presents costs involved in installing a double contact sulfuric acid plant and necessary support facilities. Costs for a single contact plant are also presented.

3.4.1 Acid Plant

The design for the acid plant is based on simultaneous operation of three converters in the blowing mode. Only in very rare cases (less than 5% of the time) do four converters blow simultaneously; this occurrence can be prevented with a planned sequence of converter operations. The design calls for approximately 132,000 scfm peak gas flow with the proposed tighter hoods and water-spray cooling system (three converters at 44,000 scfm each*). With allowance for some leakage around the ESP, the design final flow is 150,000 scfm at 32°F and 29.92 in. Hg. At an SO_2 concentration of 4.5 percent in the feed gases, this plant could produce 55.1 tons per hour (1323 ton/day) of acid (100% basis); at 6 percent SO_2, production would be 1,764 tons/day. Actual product strength would be 93.2 percent. Based on the concentrate feed rates over the last year,[5] the maximum and

* Based on 1:1 dilution of converter gases and corrected to 70°F.

Table 3-5. ACID PLANT TIE-IN DUCTING CAPITAL COSTS

Direct Costs	Material	Labor
Equipment (including ducting)	$301,000	$ 74,000
Instrumentation	incl. in equip.	
Piping	negl.	negl.
Electrical	2,000	3,000
Foundations	6,000	12,000
Structural	37,000	9,000
Sitework	negl.	negl.
Insulation	10,000	23,000
Painting	negl.	negl.
Subtotal	$356,000	$121,000
Total direct cost (TDC)		$477,000

Indirect Costs		
Contractor's fee and expenses @ 7 % of TDC	$ 33,000	
Engineering @ 10 % of TDC	48,000	
Interest during construction @ 9% of TDC for 6 mos.	21,000	
Freight @ 5% of material	17,000	
Off-sites @ 1.5% of TDC	negl.	
Taxes @ 4% of material	14,000	
Allowance for shakedown @ 2 % of TDC	10,000	
Spares @ .5% of material	2,000	
Total indirect costs	$145,000	
Total Cost		$622,000
Contingency @ 5% and escalation @ 7.5% of total cost		78,000
Total installed cost		$700,000

Table 3-6. ANNUAL OPERATING COSTS FOR CONNECTING DUCTWORK

Cost Component			Annual cost, $
Utilities			
Water			None
Electricity			None
Operating Labor			
Direct			None
Supervision	@ 15% of labor		None
Maintenance			
Labor and materials	@ .5% of total installed cost		4,000
Supplies	@ 20% of labor and materials		1,000
Overhead			
Plant	@ 50% of operation and maintenance		3,000
Payroll			None
Fixed Costs			
Depreciation	6.67%		
Interim replacement	0.35%		
Insurance	0.30%		
Taxes	4.00%		
Interest	9.00%		
Σ = 20.32% of total installed cost			142,000
Total annual cost			$150,000

average daily acid production rates would be 975 and 675 tons (100% basis), respectively.

Converter operation is irregular and is based largely on the production of matte from the roaster-reverberatory furnace system. After installation of the acid plant, this smelter will probably continue to operate under a Supplementary Control System (SCS), in which the plant operates at a curtailed rate part of the time and at a higher rate for the balance of the time. Maximum converter operation could result in above-average SO_2 concentrations in the combined converter exit stream for periods of a few hours. The plant as designed could handle concentrations up to 6 percent SO_2 continuously, with SO_2 concentrations in the tail gas not exceeding 500 ppm. The plant could also handle short-term excursions up to about 9 percent SO_2. If additional catalyst is added at a cost of about $80,000, the plant can handle higher SO_2 concentrations.

The acid plant would be located on company property in an open, flat area east of the existing spray pond, as shown in Figure 3-6. Figure 3-7 shows general area and topography of the proposed plant site.

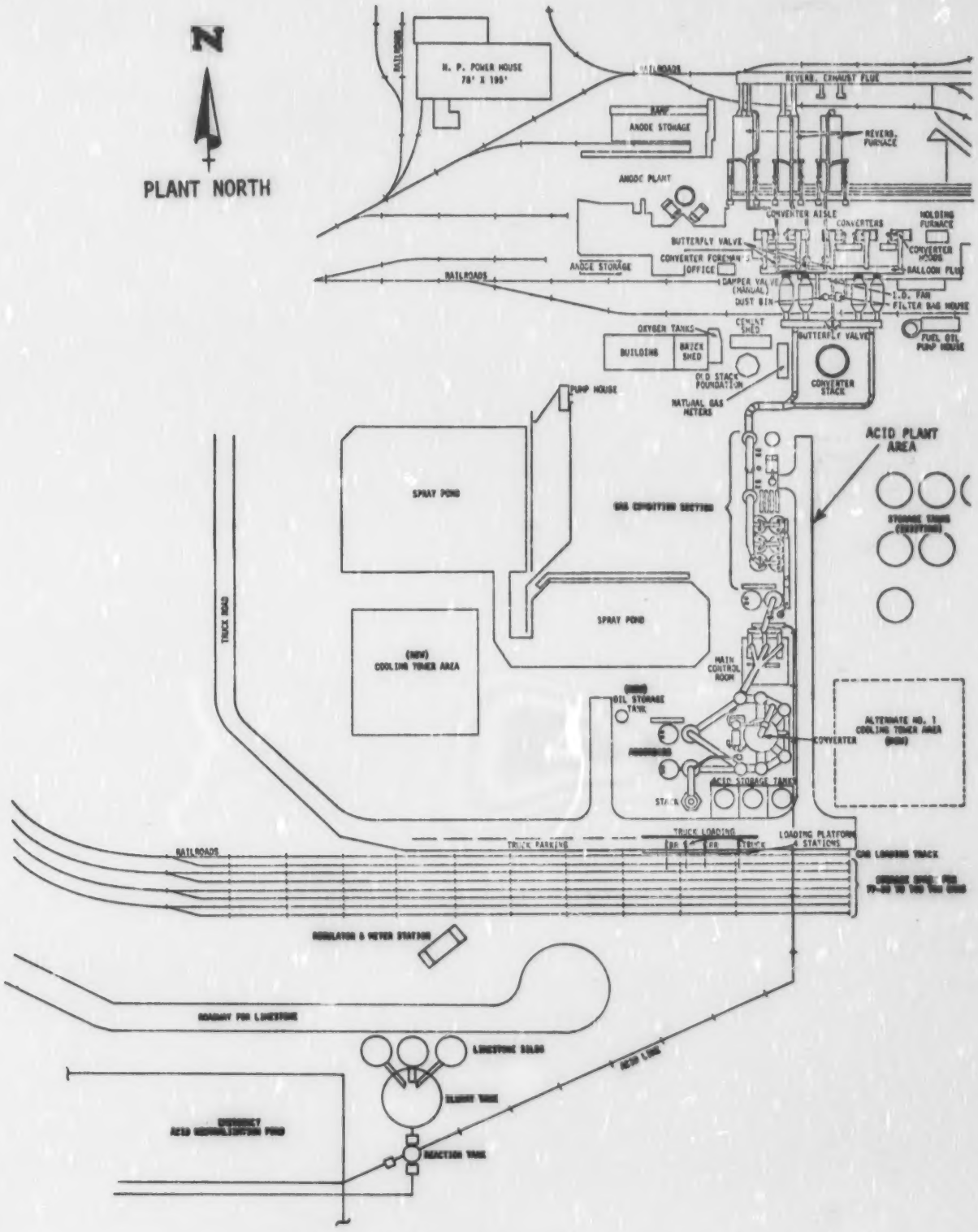


Figure 3-6. Acid plant site.

Figure 3-7. View of proposed acid plant area.

The converter gas stream would enter a gas conditioning system consisting of a spray chamber, a washing tower, and electrostatic precipitators. This section of the plant would cool and clean the gas prior to the gas drying and heating steps. The water initially sprayed into the gas stream to cool the gases would be condensed, neutralized, and sent to a clarifier for recycle to the spray system.

The cleaned gases then would enter a drying tower, the main gas blowers, and the gas heating system before entering the first stage of the catalytic converter. During start-up or when the feed gas is extremely low in SO_2, an oil-fired gas preheater would heat the gases to the temperature required

for catalytic reaction. The converter would consist of two double stages, with the gases passing through an absorber before they enter the second converter stage. Each stage would contain two beds of catalyst, providing a total catalyst charge of 290,000 liters. After the second catalyst stage, the gases would enter the final absorber and then exit through a 149-foot stack. The acid plant equipment list and basic cost estimating data are included in Appendix A.[6] A process and instrument diagram, plan view and various equipment sections are shown in Appendix B.

The total installed cost for the double contact acid plant is $50,548,000, as shown in Table 3-7. Major equipment amounts to $14,524,000, with total direct charges at $26,131,000. Indirect costs total $12,752,000. Contingency and escalation factors are projected over a 3-year period.

Annual operating costs for this plant consist largely of utilities (8650 kWh of electricity) and operating labor (average 39 people per week). Direct operating costs, as shown in Table 3-8, amount to $4,354,000 per year. Fixed costs, including a 15-year amortization, add another $10,271,000, giving a total annualized cost of $14,625,000 before any credit for acid product. At a production rate of 675 tons of acid per day (100% basis) and an acid selling price of $40 per ton,[7] approximately $9,800,000 could be recovered annually in product sales.

A simplified schedule for construction of this plant is shown in Figure 3-8. Completion would require approximately 34 months.

Table 3-7. DOUBLE CONTACT ACID PLANT CAPITAL COSTS

Direct Costs	Material	Labor*	
Equipment	$14,524,000	$4,357,000	
Instrumentation	207,000	59,000	
Piping	1,821,000	1,359,000	
Electrical	850,000	727,000	
Foundations	110,000	677,000	
Structural	331,000	499,000	
Sitework	71,000	71,000	
Insulation	61,000	270,000	
Painting	10,000	127,000	
Subtotal	$17,985,000	$8,146,000	
Total direct cost (TDC)		$26,131,000	
Indirect Costs			
Contractor's fee and expenses @ 20% of TDC		$ 5,226,000	
Engineering (based on hours required)		870,000	
Interest during construction @ 9% of TDC over 3 yrs = 18%		4,703,000	
Freight @ 3.3% of material		594,000	
Off-sites @ 1.4% of TDC		373,000	
Taxes @ 4% of material		720,000	
Allowance for shakedown (estimated)		50,000	
Spares @ 1.2% of material		216,000	
Total indirect costs		$12,752,000	
Total Cost			$38,883,000
Contingency @ 5% over 3 yrs = 5.8%			2,255,000
Escalation over 3 yrs = 24.2			9,410,000
Total installed cost			$50,548,000

* Includes field erection.

Table 3-8. ANNUAL OPERATING COSTS FOR DOUBLE CONTACT ACID PLANT*

Cost Component		Annual cost, $
Limestone	0.37 ton/hr @ $6/ton	$ 19,000
Utilities		
Water	964 gpm @ $0.1257/1000 gal.	67,000
Electricity	8650 kWh @ 30.5 mills/kWh	2,216,000
Start-up fuel	8 gpm @ $13/bbl	7,000
Operating Labor		
Direct	39 men/wk @ $7.066 man/hr	598,000
Supervision	@ 15% of direct labor	89,000
Maintenance		
Labor and materials	@ 1% of total installed cost	505,000
Supplies	@ 15% of labor and materials	80,000
Overhead		
Plant	@ 50% of operating labor and matl.	636,000
Payroll	@ 20% of operating labor	137,000
Fixed Costs		
Depreciation	6.67%	
Interim replacement	0.35%	
Insurance	0.30%	
Taxes	4.00%	
Interest	9.00%	
Σ = 20.32% of total installed cost		
Total installed cost		10,271,000
Total annual cost		$14,625,000*

* Without credit for production of about 245,000 tons of acid per year (100% basis).

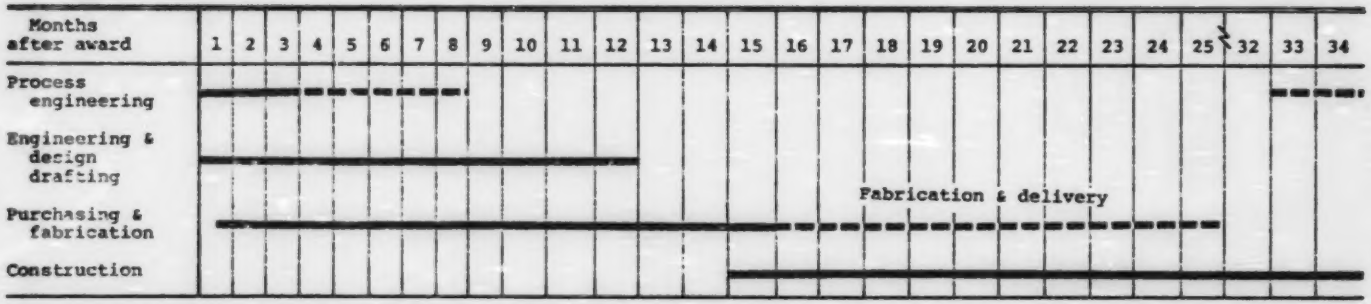


Figure 3-8. Acid plant engineering and construction schedule.

For a single contact acid plant of the same size and with a maximum tail gas SO_2 concentration of 2,600 ppm, the estimated total installed cost would be $44,320,000. This cost was obtained be deleting equipment such as the final absorber, three heat exchangers, and a number of pumps and tanks not required for a single contact acid plant.

In addition, costs of other equipment such as the main blower, structures, insulation, and instruments were reduced by applying factors to account for the smaller sizes or amounts of equipment required. These reductions yield a total direct cost (TDC) of $22,110,000 as compared to the cost of $26,157,000 for the double contact plant.

Annual direct operating costs would decrease only slightly. Because of the lower total installed cost, the total annual costs would decrease to $13,135,000.

3.4.2 Acid Storage and Transportation Facilities

An acid storage facility could be located south of the proposed acid plant, as shown in Figure 3-6. The acid storage facilities are based on an average daily production rate of 725 tons of 93 percent acid (675 tons of 100% acid). This is equivalent to approximately 100,000 gallons of acid per day. As shown in Figure 3-9, a total storage capacity of 720,000 gallons was selected, yielding a 7-day storage capacity. Since this smelter is served by highway and rail facilities (Southern Pacific), the acid can be shipped by

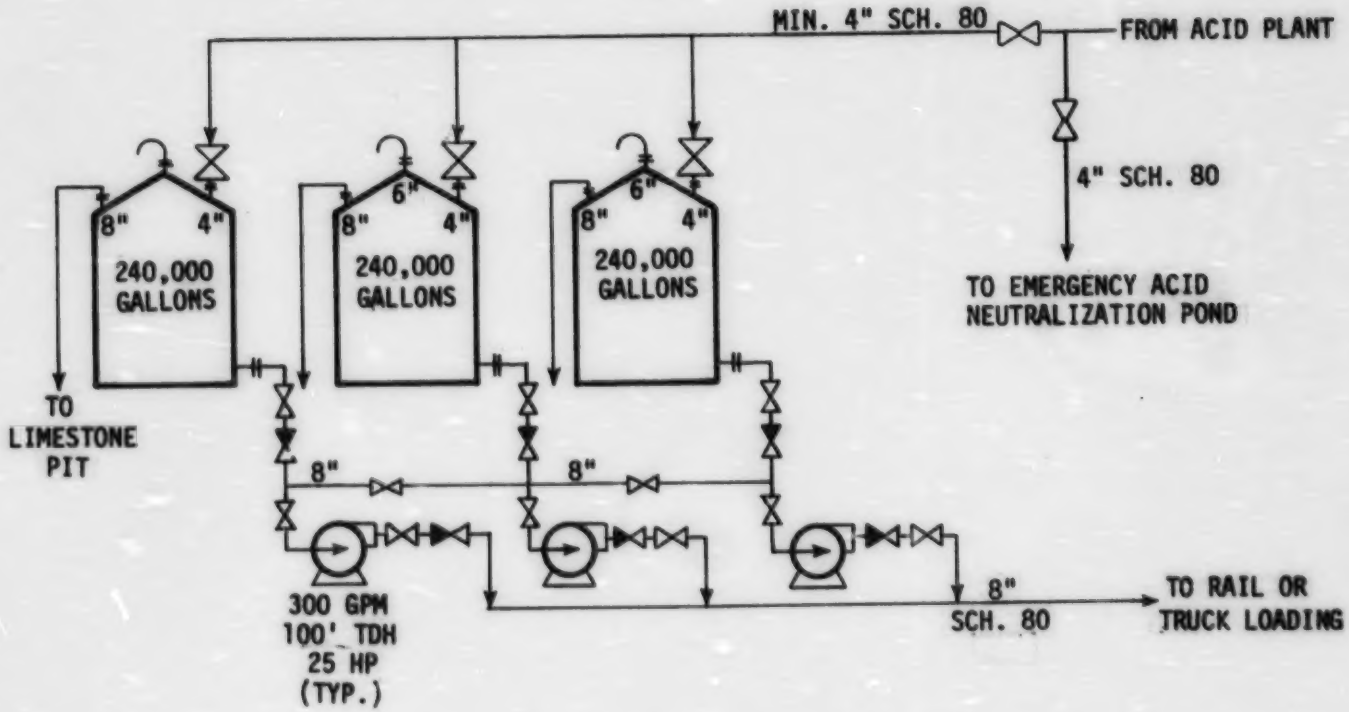


Figure 3-9. Acid storage and pumping facilities.

both methods. The storage facility would consist of three 240,000-gallon tanks, which also act as a surge chamber during any peak acid production periods. This arrangement allows for a fairly constant loading operation irrespective of smelter operation. Additional storage tanks could be located in this area.

The pumping and loading facilities could handle a loading rate of 300 gpm. This rate allows for positioning and filling a 100-ton railroad car in about 1 hour.

The total installation cost for the acid storage and loading facilities is $1,643,000, as shown in Table 3-9. Direct annual operating costs, consisting mainly of labor for the car-loading operation (two men full time), total $295,000. Fixed costs add another $338,000 per year, yielding a total annual cost of $629,000, as shown in Table 3-10.

3.4.3 Rail and Road System

Facilities for moving tank cars and trucks would be required to transport the product acid. Storage for about 60 cars must be provided for assembly of a unit train; thus, trackage for about 100 cars would be provided to allow for storage and movement. The facilities could handle either 33-ton or 100-ton cars. The track layout is shown in Figure 3-6. The total required trackage is approximately 10,300 feet, including eight spurs for storing or loading, at eleven cars per spur.

Table 3-9. ACID STORAGE AND LOADING FACILITIES CAPITAL COSTS

Direct Costs	Material	Labor
Equipment	$148,000	$ 37,000
Instrumentation	8,000	10,000
Piping	70,000	80,000
Electrical	10,000	15,000
Foundations	40,000	210,000
Structural	50,000	37,000
Sitework	17,000	20,000
Insulation	negl.	negl.
Painting	1,000	5,000
Subtotal	$344,000	$414,000
Storage tanks	$300,000*	
Total direct cost (TDC)		$1,058,000

Indirect Costs		
Contractor's fee and expenses @ 20% of TDC less tanks	$152,000	
Engineering @ 12 % of TDC less tanks	91,000	
Interest during construction @ 9% of TDC for 6 mos.	48,000	
Freight @ 5% of material	17,000	
Off-sites @ 4% of material and labor	30,000	
Taxes @ 4% of material and tanks only	20,000	
Allowance for shakedown @ 2 % of TDC	21,000	
Spares @ 6.5% of material	23,000	
Total indirect costs	$402,000	
Total Cost		$1,460,000
Contingency @ 5% and escalation @ 7.5% of total cost		183,000
Total installed cost		$1,643,000

* Turnkey installation.

Table 3-10. ANNUAL OPERATING COSTS FOR ACID STORAGE AND LOADING FACILITIES

Cost Component		Annual cost, $
Limestone (for overflow)		$ 2,000
Utilities		
Water		negl.
Electricity		6,000
Operating Labor		
Direct	2 people full time @ $7.066/hr	124,000
Supervision	@ 15% of labor	19,000
Maintenance		
Labor and materials	@ 1.4% of total installed cost	23,000
Supplies	@ 25% of labor and material	6,000
Overhead		
Plant	@ 50% of operating labor and matl.	86,000
Payroll	@ 20% of operating labor	29,000
Fixed Costs		
Depreciation	6.67%	
Interim replacement	0.35%	
Insurance	0.30%	
Taxes	4.00%	
Interest	9.00%	
Σ = 20.32% of total installed cost		
Total installed cost		$334,000
Total annual cost		$629,000

A 50-ton diesel locomotive would move the cars for unit train assembly, and a 35-ton diesel locomotive would place the cars in the loading area. The loading platform would permit simultaneous loading of two tank cars.

Adjacent to the railroad loading platform would be a truck loading station with capability for simultaneous loading of two trucks. Truck and service roadways would be approximately 1800 feet long, the widths ranging from 25 to 40 feet. A 20,000-gallon (90-day) tank for storage of No. 2 diesel oil fuel would be provided in this area.

Capital and annualized costs for the acid transportation facilities are shown in Tables 3-11 and 3-12, respectively. The major capital cost items are tracks at $829,000 and two locomotives at $309,000 (included under equipment). The total installed cost is $1,589,000. Annualized costs amount to $843,000, consisting largely of operating labor and fixed costs.

3.4.4 Short-Term Acid Disposal Pond

A short-term acid disposal pond would provide for continuous smelter operation in the event of problems with transport of marketing of the acid. A long-term disposal system is described in Section 3.7. The emergency pond would be located southwest of the existing spray ponds. The system would include a stainless steel pipeline at the tank farm storage area crossing the railroad track to a reaction

Table 3-11. ACID TRANSPORTATION SYSTEM CAPITAL COSTS

Direct Costs	Material	Labor
Equipment	$326,000	$ 3,000
Instrumentation	negl.	negl.
Piping	3,000	4,000
Electrical	2,000	3,000
Foundations	6,000	19,000
Structural	negl.	negl.
Insulation	negl.	negl.
Painting	negl.	negl.
Subtotal	$337,000	$ 29,000
Tracks	$829,000*	
Total direct cost (TDC)		$1,195,000

Indirect Costs		
Contractor's fee and expenses @ 15% of TDC less tracks	$ 55,000	
Engineering @ 10% of TDC less tracks	37,000	
Interest during construction @ 9% of TDC for 6 mos.	54,000	
Freight @ 5.6% of material less tracks	19,000	
Off-site	negl.	
Taxes @ 4% of material	30,000	
Allowance for shakedown @ 0.8% of TDC	10,000	
Spares @ 1.0% of TDC	12,000	
Total indirect cost	$217,000	
Total Cost		$1,412,000
Contingency @ 5% and escalation @ 7.5%		177,000
Total installed cost		$1,589,000

* Turnkey installation

Table 3-12. ANNUAL OPERATING COSTS FOR ACID TRANSPORTATION SYSTEM

Cost Component		Annual cost, $
Utilities		
Electricity		negl.
Water		negl.
Fuel oil	233.8 gpm,* 350 days/yr @ $13.28/bbl	26,000
Operating Labor		
Direct	3.5 people @ $7.066/hr	216,000
Supervision	@ 15% of labor	32,000
Maintenance		
Labor and materials	@ 2.5% of total installed cost	38,000
Supplies	@ 25% of labor and materials	10,000
Overhead		
Plant	@ 50% of operation and maintenance	148,000
Payroll	@ 20% of operating labor	50,000
Fixed Costs		
Depreciation	6.67%	
Interim replacement	0.35%	
Insurance	0.30%	
Taxes	4.00%	
Interest	9.00%	
Σ = 20.32% of fixed investment		
Total installed cost		$323,000
Total annual costs		$843,000

* for locomotives

tank for neutralization. The reaction tank (13 feet in diameter) would receive limestone slurry from a 75-foot-diameter slurry tank and hold it for reaction with sulfuric acid. The neutralized product would be pumped by one of two pumps to the pond area.

Three limestone silos (900 tons capacity each) would provide 3-day storage and permit continuous operation of the neutralization facility in case of an interruption in limestone supply. It is assumed that the limestone would come from a quarry less than 10 miles away and would be conveyed pneumatically from trucks into the silos.

An emergency pond for 350 days storage would require 1715 acre-feet or 34.4 acres at a 50-foot depth. Cross-sectional area of the dike would be equivalent to the earth removed, and the prepared surface of the pond would be covered with a 30-mil-thick chloride polyethylene sheet covered with a 12-inch base of sand or dirt.

Total cost for this pond would be $4,820,000, as shown in Table 3-13. The major costs are for pond preparation and the liner. The annual operating cost for 350 days would be $3,398,000, as shown in Table 3-14, the major cost item being limestone.

As an alternative to the 350-day pond, a 30-day emergency pond would require 147 acre-feet or 7.4 acres at a depth of 20 feet. It also would have a liner with a dirt or sand base.

Table 3-13. EMERGENCY ACID DISPOSAL POND CAPITAL COST

Direct Costs	Material	Labor	
Equipment	$ 312,000	$ 47,000	
Instrumentation	12,000	12,000	
Piping	40,000	60,000	
Electrical	12,000	18,000	
Foundations	39,000	115,000	
Structural	25,000	27,000	
Sitework	1,000	5,000	
Insulation	none	none	
Painting	none	none	
Pond and liner	1,812,000	995,000	
Subtotal	$2,253,000	$1,279,000	
Roadways		75,000	
Limestone inventory @ $6/ton (3 day supply)		17,000	
Total direct cost (TDC)		$3,624,000	
Indirect Costs			
Contractor's fee and expenses @ 3.3% of TDC		$ 119,000	
Engineering @ 1.5% of TDC		60,000	
Interest during construction @ 9% of TDC for 6 mos.		161,000	
Freight @ 2.5% of material		56,000	
Off-sites @ 2%		73,000	
Taxes @ 4% of material		90,000	
Allowance for shakedown @ 0.3% of TDC		10,000	
Spares @ 0.5% of material excluding liner		2,000	
Total indirect cost		571,000	
Total Cost			$4,195,000
Contingency @ 5% plus escalation @ 7.5%			625,000
Total installed cost			$4,820,000

Table 3-14. ANNUAL OPERATING COSTS FOR EMERGENCY ACID DISPOSAL POND

Cost Component		Annual cost, $
Limestone	37.4 tons/hr @ $6/ton	1,885,000
Utilities		
Water	1056 gpm @ $0.1257/1000 gal	67,000
Electricity	550 kW @ 30.5 mills/kWh	141,000
Operating Labor		
Direct	2 men full time @ $7.066/hr	124,000
Supervision	@ 15% of labor	19,000
Maintenance		
Labor and materials	@ 1% of total installed cost	48,000
Supplies	@ 1.5% of labor and materials	7,000
Overhead		
Plant	@ 50% of operating labor and maintenance	99,000
Payroll	@ 20% of operating labor	29,000
Fixed Costs		
Depreciation	6.67%	
Interim replacement	0.35%	
Insurance	0.30%	
Taxes	4.00%	
Interest	9.00%	
Σ = 20.32% of total installed cost		979,000
Total annual cost		3,398,000

Total cost for this pond would be $1,925,000; the annual cost for 30 days operation would be $588,000, plus $638,000 for cleanout, or $1,226,000 per year. If the pond were used more than 30 days per year, the additional annual operating cost would be $885,000, including cleanout for each 30-day period.

3.5 REROUTING OF FUGITIVE EMISSIONS FROM REVERBERATORY FURNACES

Particulate emissions from slag and metal tapping operations of the reverberatory furnaces are currently captured and vented into the converters' balloon flue system. Since these gases contain little SO_2, they dilute the converter off-gases. To prevent such dilution, these gases, which amount to about 90,000 scfm, would be routed directly to the converter stack. To accomplish this, the ducts from the matte launder, ladle, and slag fume area would be disconnected at the points where they enter the converter balloon flue and rerouted around the electrostatic precipitators, as shown in Figures 3-10 and 3-11. The ducts would then be combined into a dropout chamber (diameter, 13 feet 7 inches). The exit gases would be passed through a pipe header leading to a fabric filter system.

Each of the pulse-jet filter systems would have an air-to-cloth ratio of 5:1 and a capacity of 30,000 scfm (90,000 scfm total). A single induced-draft blower would be used.

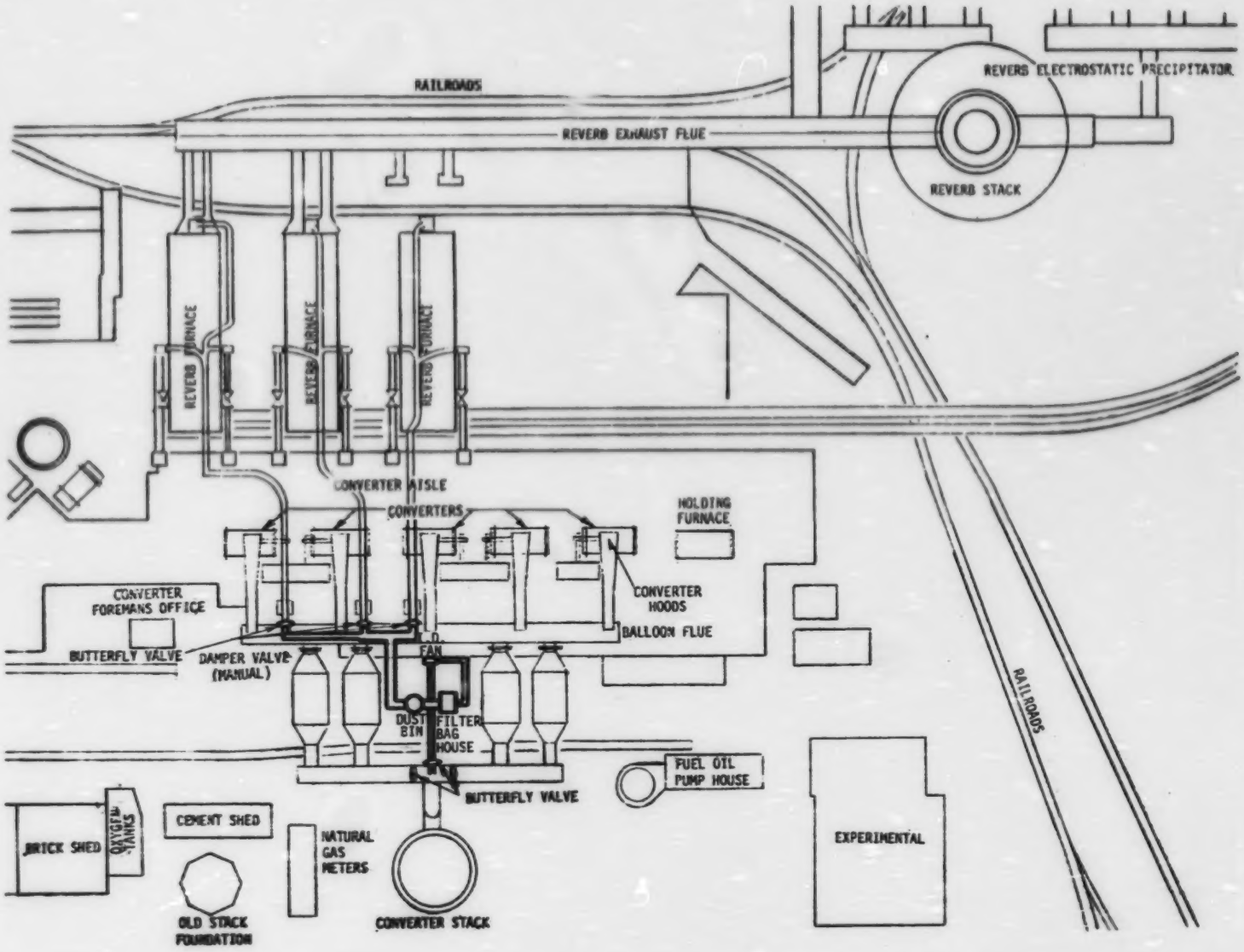


Figure 3-10. Ducting of fugitive emissions from reverberatory furnace.

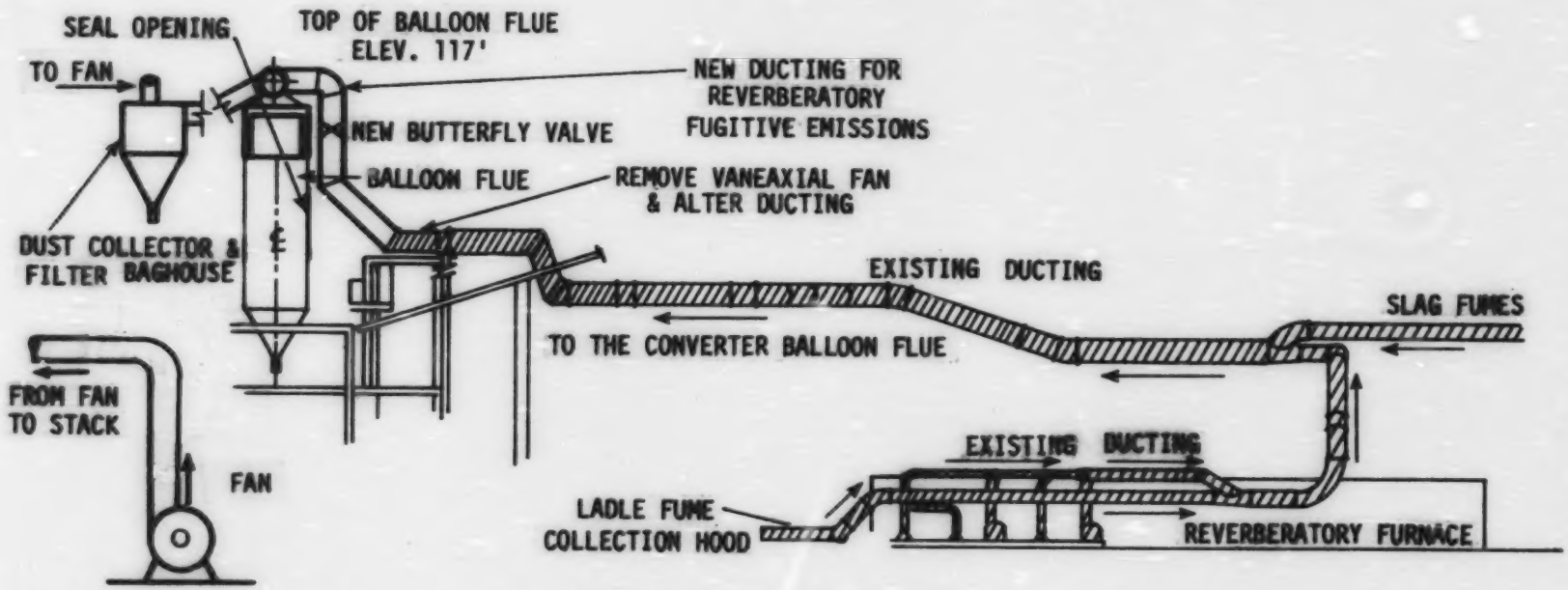


Figure 3-11. Rerouting of reverberatory furnace secondary emissions.

Flow of vent gas to each filter system would be controlled by butterfly valves. The blower valves at the baghouse and the existing butterfly valves in the ductwork would be interlocked to coordinate operation of the exhaust system with that of the reverberatory furnaces. Dust collected by the filter baghouse would be discharged via rotary valves to a silo.

The cleaned exhaust gases would discharge to a 69-inch-diameter duct into the short existing flue entering the converter stack (see Figure 3-5).

Tables 3-15 and 3-16 present the installed and annual costs, respectively, for rerouting of the reverberatory furnace gases. The capital costs amount to $1,107,000 and the annualized costs, $301,000.

3.6 ADDITIONAL ACID PLANT REQUIREMENTS

In addition to the major equipment items identified in this report, many minor items must be considered in determining total costs. Many of the individual cost summaries presented here include an off-site item to account for costs not directly related to the equipment. Examples of such costs are installation of utility lines, drains, and fencing. In addition, several major items are required to support the acid plant operation. These include an acid sludge clarifier and pumps, a fuel oil tank, an air compressor and dryer, and a fresh water well.

Table 3-15. CAPITAL COSTS FOR REROUTING OF FUGITIVE EMISSIONS FROM REVERBERATORY FURNACES

Direct Costs	Material	Labor
Equipment	$258,000	$ 75,000
Instrumentation	incl. in equip.	
Piping & ducting	134,000	70,000
Electrical	3,000	5,000
Foundations	4,000	14,000
Structural	48,000	88,000
Sitework	18,000	24,000
Insulation	negl.	negl.
Painting	negl.	negl.
Subtotal	$465,000	$276,000
Total direct cost (TDC)		$741,000

Indirect Costs		
Contractor's fee and expenses @ 9.5% of TDC	$ 70,000	
Engineering @ 12.5% of TDC	93,000	
Interest during construction @ 9% of TDC for 6 mos.	33,000	
Freight @ 2.5% of material	12,000	
Off-sites	negl.	
Taxes @ 4% of material	19,000	
Allowance for shakedown @ 2% of TDC	15,000	
Spares @ 0.5% of material	2,000	
Total indirect costs	$ 244,000	
Total Cost		$ 985,000
Contingency @ 5% and escalation @ 7.5% of total cost		122,000
Total installed cost		$1,107,000

Table 3-16. ANNUAL OPERATING COSTS FOR REVERBERATORY FURNACE GAS REROUTING

Cost Component			Annual cost,$
Utilities			
Water			negl.
Electricity			50,000
Air			negl.
Operating Labor			
Direct	one man hour shift @ 7.066/hr		8,000
Supervision	@ 15% of labor		2,000
Maintenance			
Labor and materials	@ 0.5% of total installed cost		5,000
Supplies	@ 15% of labor and materials		1,000
Overhead			
Plant	@ 50% of operating labor and maintenance		8,000
Payroll	@ 20% of operating labor		2,000
Fixed Costs			
Depreciation		6.67%	
Interim replacement		0.35%	
Insurance		0.30%	
Taxes		4.00%	
Interest		9.00%	
Σ = 20.32% of total installed cost			225,000
Total annual cost			$301,000

A cooling tower for the water in the water-cooled hood system is also required; the cooling tower for the acid plant, however, is included in that cost. These costs, itemized in Table 3-17, amount to just under $500,000. Annualized costs of about $125,000 would consist mainly of fixed charges on the capital costs, and some labor, maintenance, and utilities.

3.7 LONG-TERM ACID NEUTRALIZATION PROCESS

If needed, a long-term acid neutralization facility could be built at the smelter site. Figure 3-12 presents a simplified flow diagram and material balance for such an acid neutralization plant.

In the neutralization process, sulfuric acid (93 percent concentration) reacts with a stream of limestone slurry in a stirred reaction tank and produces gypsum:

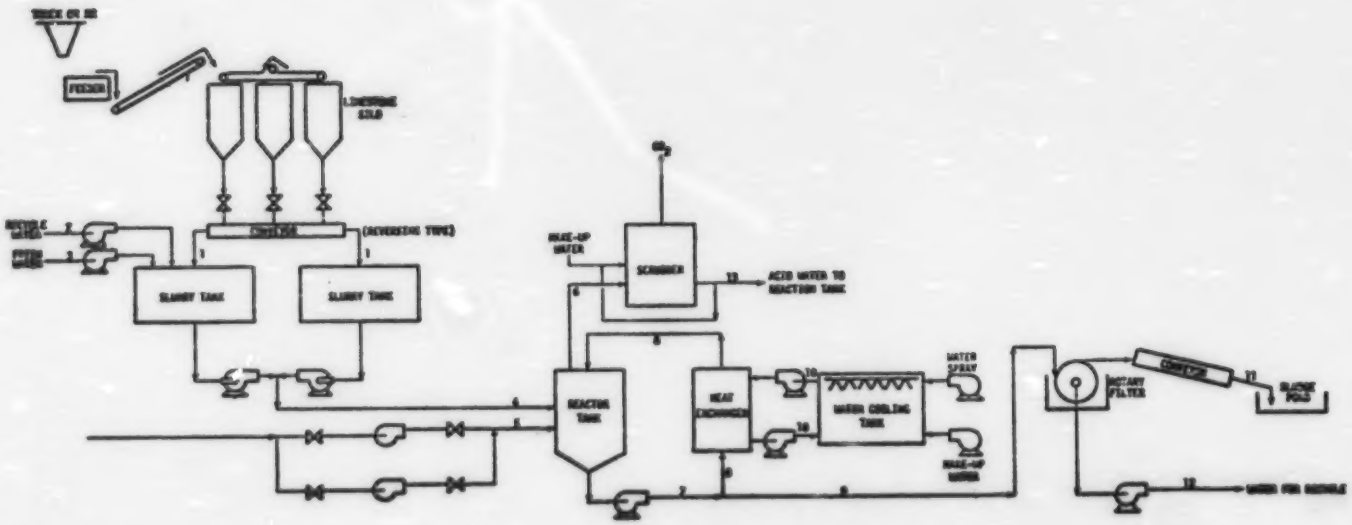
$$H_2SO_4 + CaCO_3 + H_2O \rightarrow CaSO_4 \cdot 2H_2O + CO_2$$

The reaction is exothermic and releases about 400 Btu per pound of acid (229 Btu/lb of gypsum). Limestone is fed at about 120 percent of the stoichiometric amount to allow for unreacted material. Approximately 900 tons per day of fine limestone would be required to neutralize 675 tons of acid per day. $CaSO_4$, $CaSO_3$, $MgSO_4$, and unreacted limestone would form 1200 tons per day of dry sludge.

In this process, limestone slurry (13 percent solids) is prepared by adding water to a 200-mesh limestone powder in a slurry tank. About 1,500,000 gallons per day of water

Table 3-17. CAPITAL COSTS FOR MISCELLANEOUS EQUIPMENT NEEDS RELATED TO ACID PLANT

Direct Costs	Installed Costs	
Acid sludge clarifier and pumps	$ 35,000	
Fuel oil tank for acid plant	25,000	
Air compressor and dryer	25,000	
Cooling tower and pumps	40,000	
Water well	50,000	
Instrumentation	10,000	
Foundations and sitework	35,000	
Mechanical and electrical work	100,000	
Total direct cost (TDC)	$320,000	
Indirect Costs		
Contractor's fees and expenses @ 10% of TDC	32,000	
Engineering @ 15% of TDC	50,000	
Interest during construction @ 9% for 6 mos.	15,000	
Freight @ 2% of TDC	6,000	
Taxes @ 2% of TDC	6,000	
Spares @ 2% of TDC	6,000	
Allowance for shakedown @ 2% of TDC	6,000	
Total indirect cost	$121,000	
Total Cost		$441,000
Contingency @ 5% and excalation @ 7.5%		55,000
Total installed cost		$496,000



STREAM NO.	1	2	3	4	5	6	7	8	9	10	11	12	13
DESCRIPTION	LIMESTONE TO SLURRY TANK	RECYCLE WATER TO SLURRY TANK	FRESH WATER TO SLURRY TANK	LIMESTONE SLURRY TO REACTION TANK	SULFURIC ACID TO REACTION TANK	CO_2 RELEASED FROM REACTION TANK	PRODUCT STREAM FROM REACTION TANK	PRODUCT STREAM TO HEAT EXCHANGER	PRODUCT STREAM TO ROTARY FILTER	WATER MEDIUM TO AND FROM HEAT EXCHANGER	SOLIDS FROM ROTARY FILTER	FILTRATE FROM ROTARY FILTER FOR RECYCLE	MAKE UP WATER TO SCRUBBER
RATE LBS/HR	74,760	294,578	233,562	602,900	60,483	46,962	1,581,711	976,211	615,500	602,000	320,922	294,578	6,500
GPM		589	467	1,106	70		2,868	1,750	1,109	1,004	525	589	13
SPECIFIC GRAVITY	2.71	1.0	1.0	1.09	1.73	0.002	1.11	1.11	1.11	1.0	1.214	1.0	1.0
SOLIDS, PERCENT				12.4			52.14				31		

NOTES:

1. CALCULATIONS BASED ON
   - 120% STOICHIOMETRIC LIMESTONE: 97.73% $CaCO_3$, <0.1% MOISTURE
   - 93% CONCENTRATED SULFURIC ACID
   - PRODUCTS STREAM AT 130°F
   - STREAM 8 FROM HEAT EXCHANGER IS RECYCLED BACK TO REACTION TANK

Basis = 675 tons acid per day.

Figure 3-12. Acid neutralization process - Flow diagram and material balance.

is required, mainly for slurry preparation and make-up water. On the average, about 55 percent of the total water is recovered and reused in the process. The slurry is fed to a reaction tank in controlled amounts and reacts with incoming acid to produce a stream containing calcium sulfate solids.

Heat of reaction is removed continuously by controlling the reaction tank temperature and by passing a product stream through a heat exchanger and back to the reaction tank. The product solids are continuously filtered in a rotary filter, and the filtrate water is recycled to the slurry tank. The filter cake (3850 tons per day) is conveyed continuously to an adjacent lined pond. The pond would be 50 feet deep (25 feet below ground level deep with 25-foot earth walls above ground-level) and would cover 341 acres.

The need for a liner is questionable, since this waste material is essentially inert gypsum. A thorough evaluation of groundwater flow and impact on the surrounding area would be required to determine whether a liner is required. Cost of the liner, however, is included in this estimate.

Carbon dioxide released by the reaction is treated in a water scrubber to remove water vapor, acid mist, and any carbonic acid before release to the atmosphere. Scrubber water is added to the reaction tank.

Estimated capital and annual costs for a neutralization plant handling 675 tons of acid per day are $21,205,000 and $7,601,000, respectively. The major portion of the capital goes for the sludge pond and its liner, totalling $13,553,000. Tables 3-18 and 3-19 list the capital and annual costs, respectively.

Table 3-18. CAPITAL INVESTMENT FOR ACID NEUTRALIZATION PLANT TO TREAT 675 TONS PER DAY

Direct Costs	Material	Labor	
Equipment	$2,511,000	$ 236,000	
Piping	50,000	70,000	
Electrical	50,000	71,000	
Foundations	50,000	75,000	
Structural	100,000	57,000	
Sitework	50,000	50,000	
Painting	1,000	5,000	
Subtotal	A = $2,812,000	B = $ 564,000	
Total cost of equipment (A & B)		3,376,000	
Disposal pond & liner		13,553,000	
Limestone inventory		175,000	
Total direct cost (TDC)		$17,104,000	
Indirect Cost			
Contractor's fee and expenses @ 15% of A & B		$ 507,000	
Engineering @ 10% of A & B		338,000	
Interest during construction @ 9% of TDC for 6 mos.		769,000	
Freight @ 2.5% of material		70,000	
Off-sites @ 1.5% of A & B		50,000	
Taxes @ 4% of material		112,000	
Allowance for shakedown @ 1.2% of A & B		40,000	
Spares @ 1% of material		28,000	
Total indirect cost		$ 1,914,000	
Total Cost			$19,018,000
Contingency @ 4% and escalation @ 7.5% of total cost			2,187,000
Total installed cost			$21,205,000

Table 3-19. ANNUAL OPERATING COSTS FOR ACID NEUTRALIZATION PLANT TO TREAT 675 TONS ACID PER DAY

Cost Component		Annual cost, $
Limestone	37.4 ton/hr @ $6.00/ton	$1,965,000
Utilities		
Water	700 gpm @ $0.1257/M gals.	48,000
Electricity	546 kW @ 30.5 mills/kWh	146,000
Operating Labor		
Direct labor	1 man/shift @ $7.066/hr	62,000
Supervision	@ 15% of direct labor	9,000
Maintenance		
Labor and materials	@ 1% of total installed cost	212,000
Supplies	@ 15% of labor and materials	32,000
Overhead		
Plant	@ 50% of operation and maintenance	158,000
Payroll	@ 20% of operating labor	14,000
Fixed Costs		
Depreciation	5.00%	
Interim replacement	0.35%	
Insurance	0.30%	
Taxes	4.00%	
Interest	9.00%	
Σ = 18.65% of total installed cost		3,955,000
Total annual cost		$6,601,000

CHAPTER 3 REFERENCES

1. Communication from Stearns-Roger, Inc. to J. Davis, Phelps Dodge Corp. February 6, 1976.

2. PEDCo trip report from Magma Smelter on August 24, 1976.

3. Letter from Foster Wheeler Co. to PEDCo. July 27, 1976.

4. Verbal communication from Phelps Dodge to PEDCo. June 18, 1976.

5. Communication from Phelps Dodge to Environmental Protection Agency. June 28, 1976.

6. Report by Tim J. Browder Company, San Marino, California. August 17, 1976.

7. Chemical Marketing Reporter, November 8, 1976. pg. 52.

APPENDIX A

ACID PLANT DATA

TIM J. BROWDER COMPANY

Post Office Box 5473
San Marino, CA 91108, U.S.A.
Telephone: (213) 287-7709

SPECIALIZING IN:

- DESIGN ENGINEERING
- CONSTRUCTION
- PLANT ALTERATIONS
- MODERNIZATION
- COMPLETE PLANTS

SULFURIC ACID
SULFUR
ALKYLATION
ORE ROASTING
GAS PURIFICATION
GAS DRYING
GAS COOLING
CATALYTIC REACTORS
ACID COOLING
STORAGE SYSTEMS
SULFUR DIOXIDE
SULFUR TRIOXIDE
POLLUTION CONTROL
SCRUBBERS
SINGLE CONTACT
DOUBLE CONTACT
NITRIC ACID
AMMONIUM SULFATE
AMMONIUM NITRATE
AMMONIA OXIDATION
LEAD CHAMBERS
FERTILIZER
HEAVY CHEMICALS

rec'd 8/19/76

17 August 1976

Mr. Richard Gerstle
PEDCo - Environmental
Suite 13 - Atkinson Square
Cincinnati, Ohio, 45246

Dear Mr. Gerstle:

Subject: Contract No. 68-02-1375
Task Order No. 34
Sub-contract 124-76
PN 3255-HH
(Phelps Dodge, Douglas, Arizona)

Please refer to PEDCo letter of 30 June 1975, Scope Of Work for the above reference plant.

You will find attached all items of Scope: Items 1 through Item 8.

Item 1. You will note that this acid plant is based on 150,000 scfm (32° - 1 atmos) and different gas strengths, therefore, producing different production capacities at different gas flows and strength. Based on a catalyst loading (estimate) of 290,000 liters this plant can achieve stack gas analysis of less than 500 ppm regardless of the capacity below 1,764 T/D. If additional catalyst (50,000 liters is included, the plant will achieve less than 500 ppm up to 2,058 T/D (7% SO_2 gas). See attached tabulation.

Item 2. Attached you will find an Equipment List. This list shows sizes, thicknesses, linings, rating capacities, etc.

Item 3. Attached you will find a "List Of Battery Limit Connections". This list shows peak (max.) flows, line sizes. Also please find Motor List and Connected Electrical Motors, and daily average operating H.P. of motors, KW for lighting, and K.V.A. for transformers of the E.S.P. S-2802 A - F.

Item 4. Attached you will find the final work sheets and capital cost of double contact sulfuric acid plants and single contact sulfuric acid plants. These costs include all materials, installed labor cost, direct and indirect cost, profit, overhead, etc. These cost are for a plant mechanically complete, and ready to operate. These are current pricing, and it is suggested you add minimum of 12 percent (6 percent per year) to arrive at the average constructed price two years from now. If P.D. stalls an additional year, then add another 6 percent. For startup add to this $50,000 for start-up and operator training.

Item 5. Attached you will find requirements for operating personnel, labor, and other cost (maintenance, etc.), chemicals, electric, water, etc. Please refer to Item 3 for complete details.

Item 6. A 2/3 curve price would be based on 6/10 power of 2/3 capacity or about 78 percent of the full size plant. Please find curve for typical plants enclosed. This shows a $41 mm plant at 2/3 size to be about $32 mm.

Item 7. A seperate estimate was made for a single contact plant. It is about 88 percent of the cost of a double contact plant. See attached.

Item 8. Estimate time to install a double contact plant. See construction schedule. The start-up would take an additional 2 weeks.

You will be sent, under seperate cover (in mailing tube), 3 mylar drawings for this plant.

You have now been furnished everything that we agreed to furnish under this Task No. 34 from my company.

If you have any questions, you can call me or Mr. Wm. Oliver. Mr. Oliver has been given more detailed information, and will be able to answer any questions if you cannot contact me.

Very truly yours,

Tim J. Browder
President

TJB/dj

cc: Mr. Wm. Oliver, EPA, Region IX

ITEM 1.

1.0

PRODUCTION RATE VS: FLOW & %SO_2

$$\frac{(150{,}000)\,(\%\,SO_2)\,(1440)\,(98\,\#/\#M)\,(.997)}{(2000)\,(359\,FT^3/\#M)} = 29393.4\,(x\%)$$

(CFM) MIN/D #/T

FEED GAS TO ACID PLANT	%SO_2		PRODOCTION	SO_2 STACK GAS PPM *
150,000 CFM	4.5	=	1323 T/D	< 150
	5.0	=	1470 T/D	< 300
	6.0	=	1764 T/D	< 500 (1)
	7.0	=	2058 T/D	(A)
100,000 CFM	4.5	=	882 T/D	< 100
	5.0	=	980 T/D	< 110
	6.0	=	1176 T/D	< 120
	7.0	=	1372 T/D	< 200
75,000 CFM	4.5	=	662 T/D	< 80
	5.0	=	735 T/D	< 90
	6.0	=	882 T/D	< 100
	7.0	=	1029 T/D	< 120
	↑ %SO_2		↑ T/D	↑ STACK ppm SO_2

(1) (INITAL CATALYST DESIGN TO ACHIEVE 650 PPM SO_2)

* BASED ON 290,000 LITERS OF CATALYST IN ESTIMATE. (continued)

(A) IF 340,000 LITERS USED FOR 7.0% THEN THIS WOULD BE 500 PPM SO_2 (ADDITIONAL COST @ 78-80,000 INSTALLED FOR 50,000 LITERS OF CATALYST)

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ITEM 2

PHELPS DODGE
SULFURIC ACID PLANT
DOUGLAS, ARIZONA

EQUIPMENT LIST

Item No.	Service	Description
Towers		
T-1101	Humidifying Tower	21'-0" dia. x 40'-0" with Cone Bottom, Carbon Steel, Teflon, Ppe and Carbon Brick-lining.
T-1102	Washing Tower	22'-0" x 36'-0" High, FRP
T-1103	Acid Stripping Tower	7'-0" dia. x 24'-0" High C.S., Teflon, A.P. Brick-lined.
T-1104	Drying Tower	26'-0" dia. x 26'-0" High C.S., Teflon, and Acid Proof Brick-lined. Double Gas Inlet Nozzles
T-1105	Intermediate Absorption Tower	26'-0" dia. x 26'-0" High C.S., Teflon, and Acid Proof Brick-lined. Double Gas Inlet Nozzles
T-1106	Final Absorption Tower	26'-0" dia. x 26'-0" High, C.S., Teflon, and Acid Proof Brick-lined. Double Gas Inlet Nozzles
T-1107	Weak Acid Stripper	48" dia. x 18'-0" High, FRP
T-1108	Lime Silo	8'-0" dia x 30'-0" High, C.S. with 5 HP feed screw
Heat Exchangers & Coolers		
HE-1301	Cold H.E. #1	4800 1½" dia. tubes, 10 BWG C.S., 40'-0" Long. Shell, 14'-6" dia.

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EQUIPMENT LIST

Item No.	Service	Description
Heat Exchangers & Coolers (cont'd)		
HE-1302	Cold H.E. #2	4800 1½" dia. tubes, 10 BWG C.S., 40'-0" Long, Shell, 14'-6" dia.
HE-1303	Hot H.E. #3	2400 1½ dia. tubes, 10 BWG Croloy 2Si, 24'-0" Long. Shell, 12'-6" diameter
HE-1304	Hot H.E. #4	2400 1½" dia. tubes, 14 BWG Croloy 2Si, 24'-0" Long. Shell, 12'-6" diameter
HE-1305	Cold H.E. #5	4400 1½" dia. tubes, 10BWG C.S., 40'-0" Long. Shell, 16'-0" diameter
HE-1306	Cold H.E. #6	4400 1½" dia. tubes, 10 BWG C.S., 40'-0" Long. Shell, 16'-0" diameter
HE-1307	Preheater	1800 1½" dia tubes, 24"Long, T304 SS, Shell 11'-0" dia.
HE 1308	Weak Acid Coolers	Impervious Graphite tubes 7/8" dia.,Steel Shells, 36,000 Sq. Ft.
HE-1309	Drying Tower Cooler	Chemetics - 7,210 Sq. Ft. S.S., Anodically Protected
HE-1310	Intermediate Absorber Cooler	Chemetics - 6,460 Sq. Ft. S.S., Anodically Protected
HE-1311	Final Absorber Cooler	Chemetics - 3,230 Sq. Ft. S.S., Anodically Protected
HE-1312	Product Acid Cooler	Chemetics - 720 Sq. Ft. S.S., Anodically Protected
Furnace		
F-1401	Preheater Furnace	10' dia. x 20' Long, Brick-lined

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EQUIPMENT LIST

Item No.	Service	Description
Pump & Drives		
P-1501A&B	Humidifying Tower (2)	5000 GPM - 100' TDH, 250 HP
P-1502A&B	Washing Tower Pumps	5000 GPM - 150' TDH, 350 HP
P-1503A&B	Drying Tower Pump	Lewis Size 12- 4000 GPM, 250 HP
P-1504A&B	Int. Absorber Pump	Lewis Size 12- 6000 GPM, 250 HP
P-1505A&B	Final Absorber Pumps	Lewis Size 12- 4000 GPM, 250 HP
P-1506A&B	Product & Drain Pumps	200 GPM, 120' TDH, 20 HP
P-1507A&B	Neutralization Tank	200 GPM, 100' TDH, 10 HP
P-1508A&B	Fuel Oil Pumps	8 GPM, 10 HP
P-1509 A,B, & C	Cooling Water Pumps	10,000 GPM, 120' TDH, 300 HP
Cooling Tower		
CT-1701	Cooling Tower	17,700 GPM, 310 MM BTU/Hr
Blowers		
B-1801A,B,&C	Main Gas Blowers	75,000 SCFM, 8.7 psi delta P, 5,000 HP each.
B-1802	Preheater Furnace Blower	35,000 SCFM, 15" water delta P, 150 HP
B-1803 A&B	Quench Gas Blowers	10,000 SCFM, 1 psi delta P, 100 HP
B-1804	Atomizing Air Blower	75 HP
Tanks		
TK-1901	Humidifying Tower Pump Tank	20'-0" and 14'-0" x 10' deep

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EQUIPMENT LIST

Item No.	Service	Description
Tanks (cont'd)		
TK-1902	Seal Pot	8'-0" dia. x 5'-0" deep
TK-1903	Drying Tower Pump Tank	28'-0" dia. x 10' deep Teflon & A.P. Brick-lined
TK-1904	Inter. Absorber Pump Tank	28'-0" dia. x 10' deep Teflon & A.P. Brick-lined
TK-1905	Final Absorber Pump Tank	28'-0" dia. x 10' deep Teflon & A.P. Brick-lined
TK-1906	Neutralization Pit (Tank)	16'-0" x 16'-0" x 10' deep
Reactors		
R-2501	Converter	49'-0" dia. x 50'-0" High 4 Catalyst Beds
Separation Equipment		
S-2801	Gas Liquid Separator	FRP - Integral in duct
S-2802 A,B,C,D,E&F	Electrostatic Precipitators	Each ± 240 tubes x 17'-0" dia. 3 series, 3 parallel.
S-2803	Drying Tower Demister	20'-0" dia - 2 stage-1-20' dia pad & 1-18' dia. pad
S-2804	Inter. Absorber Demister	York Type S 18'-0" dia.
S-2805	Final Absorber Demister	York Type S 19'-0" dia.
S-2806	Neutralization Tank Mixer	3 HP
Stack		
ST-2901	Stack	14'-0" dia x 149'-0" High Self Standing - Spoilers at Top 20'

List Of Battery Limit Connection
Sulfuric Acid Plant
Phelps Dodge Corporation

			GPM Max.	Size
Water				
1.	Cooling Tower Make-up Water	(40 psig.)	800	8"
2.	Emergency Water (Fire Main-OK) (@ 2 Locations) ("E")	(40 psig.)	900	8"
3.	Process (Potable)	(40 psig.)	40	2"
4.	Cooling Water (By T.J.B. Co.)	---------	---	---
Fuel				
			(GPM)	
1.	Start-up Fuel (#2) (Max. 48 Hrs.)	(0-20 psig.)	8	1½"
Instrument Air				
			(SCFM)	
1.	Dried (-40°F)	(50 psig.)	120	2"ø
2.	Utility	(50 psig.)	120	2"ø
Acids				
			(GPM)	
1.	Product - 66°Be' (93.2%)	(sp.gr. 1.8)	200	4" DI
2.	Weak Acid Sludge (Lined)	(FRP Pipe)	120	4" FRP

Electrical

See Attached

ITEM 3

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(A)

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San Marino, CA 91108 USA

PHELPS DODGE CORPORATION
SULFURIC ACID PLANT
(150,000 SCFM GAS FLOW)

REV = 0
8-1-76

Sulfuric Acid Plant

Motor List

Name	Connected	Average Operating
Lime Silo Feed Screw	5	3
Humififying Tower Circ. Pump	350	300
(Spare)	350	---
Washing Tower Circ. Pump	250	200
(Spare)	250	---
Neutralization Tk. Pumps (Sump)	10	6
(Spare)	10	---
ESP - Seals Fans	(3) 3/Each	6 Total
Drying Tower Pump and Spare	250 (2)	180
Absorp. # 1 Pump	250	210
(Spare)	250	---
Absorp. #2 Pump	250	205
(Spare)	250	---
Main Gas Blower	5000	3800
Main Gas Blower	5000	3800
(Spare)	5000	---
Quench Gas Blower	100	76
Start-up Lubr. Pump (Main Blower)	10	---
Start-up Lubr. Pump (Main Blower)	10	---
(Spare)	10	---
Preheater Furnace Blower	150	---
Atomiz. Fuel Blower	75	---
Drain (Product) Pump	20	18
(Spare)	20	---
Fuel Oil Pump (Start-up)	10	---
(Spare)	10	---
Blower Room Exhauster	2	1½
Utility Air Compressor	25	5
	18,176 HP	8810.5 HP
6 Mist Precipitators (3)	50 KVA/Each	90 KVA Total

Acid Plant (No Control Room, No Lights, No. Cooling Tower)		Connected	Operating
(A) Normal Average (Acid Plant	Plus	18,176 HP (150 KVA)	8,810.5 HP (90 KVA)

(B)

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Water Cooling Tower		(Connected)	(Average Operating)
C.T. Well Pump (1000 GPM)	85'	300	290
C.T. Well Pump "	85'	300	290
Spare "	----	300	---
Cooling Tower Fan	----	150	140
Cooling Tower Fan	----	150	140
Cooling Tower Fan	----	150	---
(B)	Total	1350 HP	860 HP

Control Room (Motors)

Instruments	16 x 1/8 =2	1½
Air Conditioning (Heating)	20	10
(C) Total	22 HP	11.5 HP

Total Plant Lighting

(D) All Lights	100 KW	60 KW

©

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91108, U. S. A.

ITEM 4

Summary of Total Cost - DC/DA

Total Major Equipment	14,523,800
Total Direct Material	6,550,700
Total Equipment & Material	21,074,500
Total Field Costs	14,752,200
Total Constructed Cost	35,826,700
Home Office Costs - Payroll	750,480
Overhead	600,380
Contingency - 5% of Constr. Cost	1,791,340
Fee - 5% of Constr. + Contingency	1,880,900
Total Plant Cost	40,849,800

COST OF DOUBLE CONTACT PLANT 8/76 FOR 150,000 SCF (32°F - 1 ATMOS) TO PRODUCE <500 PPM SO_2 UP TO 6% SO_2 GAS. IF 7% GAS ADD $77-80,000 for 50,000 LITERS OF ADDITIONAL CATALYST. SUGGEST 6% ESCULATION/YEAR. AVERAGE EQUIPMENT PURCHASED & CONSTRUCTED 2 yrs. (1.12 x $41 MM). IF CONSTRUCTION DELAYED 1 YEAR BY P.D. add additional 6%.

Add $50,000 TO START-UP & TRAIN OPERATORS

ESTIMATE ±15%

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ENGINEERING & Home Office Costs

	Manhours	$/MH	Cost
Instrument	1800	9.60	17,280
Piping	12,800	9.60	122,880
Structural	5800	9.96	57,770
Chemical	2200	9.58	21,080
Electrical	3600	9.96	35,860
Mechanical	5800	10.88	63,100
Total Eng./Des.	32,000		317,970
Supervision	260	15.46	4,020
Project Mgmt.	4000	13.98	55,920
Process	1000	12.71	12,710
Planning	800	7.88	6300
Job Coordination	2000	9.92	19,840
Project Services	400	6.40	2,560
Total Eng. Admin.	8460		101,350
Total Des/Admin.	40,460		419,320
Clerks	800	4.64	3,710
Secretarial	2800	4.56	12,770
Total Steno./Clerk	3600		16,480
Purchasing	6600	7.32	48,310
Expediting/Insport.	2400	7.32	17,570
Accounting	1800	4.76	8,570
Cost Engr.	2100	9.17	19,260
H.O. Construction	2400	11.00	26,400
Total Other Depts.	15,300		120,110
Total Salary	59,360	9.37	555,910
Fringe Benefits		35%	194,570
Total Payroll			750,480

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Phelps Dodge H_2SO_4 Plant

	Description	Total	
1100	Towers	1,957,700	✓
1300	Heat Exchangers	5,296,800	✓
1400	Furnace.	139,500	✓
1500	Pumps	362,200	✓
1700	Cooling Tower	499,000	✓
1800	Blowers	932,800	✓
1900	Tanks	472,400	✓
2500	Reactor	1,314,400	✓
2800	Separation Equipment	3,225,200	✓
2900	Stack	323,800	✓
	Total Major Equipment	14,523,800	
4100	Concrete Work & Excavation.	787,000	✓
4200	Pipe, Ducts, Valves, Fitlings	1,688,800	✓
4300	Structural Steel	[illegible]	✓
4400	Instruments & Controls	266,000	✓
4500	Painting	137,000	✓
4600	Electrical & LIGHTING.	1,255300	✓
4700	Insulation	330,900	✓
4800	Paving & Fences	142,100	✓
4900	Buildings	158,000	✓
6200	Catalyst - 290,000 l @ $1.50/l	435,000	✓
	Total Direct Material	6,550,700	-
	Total Equipment & Material	21,074,500	-
	Total Field Costs 0.7 × Eq. & Mat'l	14,752,200	-
	Total Constructed Cost	35,826,700	-

Tim J. Browder
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4100 Foundations & Concrete Structures

	Cu. yds.
T-1101	84
1102	92
1103	12
1104	127
1105	127
1106	127
1107	3
1108	14
HE 1301	46
1302	46
1303	20
1304	20
1305	46
1306	46
1307	13
1308 A B C D & E	50
1309	15
1310	15
1311	15
1312	12
F-1401	35
P-1501 A & B	7
1502 A & B	7
1506 A & B	4
1508 A & B	3
CT-1701	360

	Cu. yds.
B-1801 A, B & C	99
B-1802	13
B-1803 A & B	26
B-1804	10
Tk-1901	38
TK 1902	7
Tk-1903	98
Tk-1904	98
Tk-1905	98
Tk-1906	34
R-2501	473
S-2802 A, B, C D, E & F	360
ST-2901	45
Total	2745

2745 × 275/cu yd = 755,000 lbs

Excavation 8,000 cu yds
8,000 × 4 = 32,000

Total Concrete & Excavation = 787,000

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4200 Piping

	Quantity	Unit	Materials & Expense	Labor M.H.	Total
C.S. Piping 16" Av. Dia.	3600	L.F.	226,800	8200	
Vitrif. Clay Piping 24" Av. Dia.	80	L.F.	5,200	200	
Safety Shower Piping 2" Av. Dia.	900	L.F.	20,300	1,250	
Instrum. Air Piping 2" Av. Dia.	600	L.F.	1500	500	
Cost Iron Piping 11" Av. Dia.	2050	L.F.	162,100	6900	
PVC & FRP Piping 11" Av. Dia.	900	L.F.	131,100	2700	
				19,750HH	
Total Piping			547,000	489,800	1,036,8
FRP Ducts					
Materials			400,000		
Labor	730	MH		18,100	
Total			400,000	18,100	418,10

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4200 Piping (cont.)

Metal Ducts	Quantity	Unit	Cost/Unit	Materials & Expense	Labor	Total
1¼ Cr-½Mo Ducts	18,400	lb.	2.10	38,600		
C.S. Ducts	481,000	lb	1.32	634,900		
Aluminize	3590	ft²	5.50	19,700		
Dampers, C.S.	6700	lb.	2.71	18,100		
Damper Operators	7	EA	2000	14,000		
Expans. Jts. (4) 1¼ Cr-½Mo.	7600	lb.	2.80	21,300		
Expans Jts. C.S. (22)	48,000	lb.	1.66	79,700		
Butterfly Valves	4	EA.	12,000	48,000		
Total	14,500	MH	24.80	874,300	359,600	1,233,900

Total Piping & Ducts 2,688,800

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4300 STRUCTURAL STEEL

	Quantity	Unit	Cost Unit	Materials & Expense	Labor	Total
Grillage Beams	152,000	lbs	.60	91,200		
Light ...	13,100	lbs.	.75	9,800		
...	1840	MH				
Ladders & Platforms						
Ladders & Cages	7,200	lbs	1.35	9,700		
Platforms	60,500	lbs	1.18	71,400		
Handrails	6800	lbs	1.22	8,300		
Stair Treads	1500	lbs	1.36	2000		
	2150	MH				
Pipe Supports	30,000	lbs	.67	20,100		
	480	MH				
Misc.	16,300	lbs	1.12	18,300		
	360	MH				
Total	4830	MH	24.80	230,800	119,800	350,600

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4400 Instruments & Controls

Instruments (140). Cost	207,000
Labor - S/C Installation (2400 MH).	59,000
Total Instruments	266,000 ✓

4500 Painting

Ductwork	13,300 SF		
Stack	6600		
Vessels & Equipment	27,500 SF		
Steel	38,900		
Piping	33,900		
Total	120,200	× 1.14/SF	137,000 ✓

4600 Electrical

19,800 HP × # 63.40/HP = 1,255,300 ✓
Incl lighting, instruments etc.

4700 Insulation

Heat Exchangers -	15,100 SF	- 3" RW@7.60	114,800 ✓
Converter	9,900 SF	4" RW@8.40	83,200 ✓
Ducts	19,100 SF	2" RW@6.80	129,900 ✓
Misc. Allow			3,000 ✓
Total Insulation			330,900 ✓

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4800 Paving & Fences

Acid Proof Paving	200 SF @ 23	5,000
Curbs - Transformer	200 SF @ 20	4,000
Fence - Transformer	200 LF	3,600
Excavate & Backfill	3600 C.Y. @ 3	10,800
Paving - 4"	80 CY @ 220	17,600
6"	360 CY 250	90,000
Crushed Stone	740 CY 15	11,100
Total Paving, Fences, etc.		142,100

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4900 Buildings

Control Building
20' × 72' incl.
lav., lab. & MCC
Allow 158,000

ITEM 5.

5. SCOPE OF WORK

OPERATING LABOR (DIRECT)	PER DAY
OPERATING LABOR (1) (8 HRS/SHIFT)	8 MEN (1)
SUPERVISION (1 MAN - 8 HRS)	1 MAN.
MISC. MAINTENANCE (AVERAGE)	9 MEN. (2)
CHEMICAL TESTER	1 MAN
	19

OPERATING LABOR (2~3 WEEKS/YEAR)	(AVER./DAY)
BASED ON 50#/T (AV. 1000 T/D) Maintenance	$500.00/DAY.
CHEMICAL (MISC.) (LIME ETC)	$900.00/DAY
LUBRICATION, MISC	$100.00/DAY
COOLING WATER MAKEUP (MISC)	—
900 GPM AV. MAX 1400	1,296,000 GPD
ELECTRIC (SEE ATTACHED)	
BHP (24 HR)(.745)/.85 Eff	207,537 KWHR

(1) ACID PLANT 2 MEN PER SHIFT = (6) PLUS. 2 INC VACATION LABOR, ACID LOADING, STORAGE ETC.

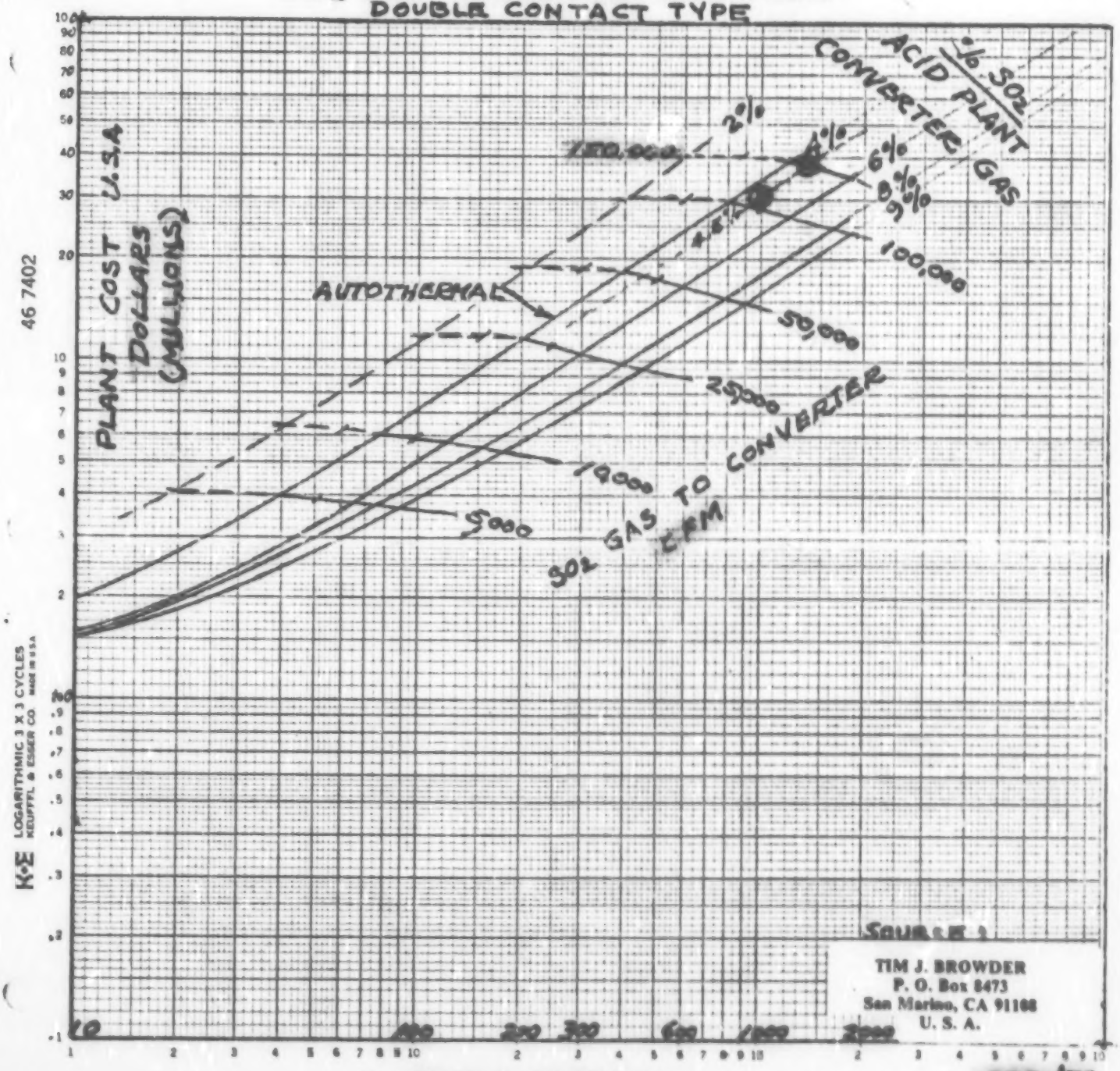
(2) AVER 3 MEN PER SHIFT - NO EXTRA FOR VACATIONS ETC.

ITEM 6

CDC-1

COST - METALLURGICAL (COPPER SMELTING) SULFURIC ACID PLANTS AT DIFFERENT SO_2 GAS STRENGTHS AND FLOW~

DOUBLE CONTACT TYPE



46 7402

K·E LOGARITHMIC 3 X 3 CYCLES KEUFFEL & ESSER CO MADE IN U.S.A.

SOURCE #3

TIM J. BROWDER
P. O. Box 8473
San Marino, CA 91108
U. S. A.

FEB '76

8/76 = 1.03
2/77 = 1.06
3/78 = 1.12
4/79 = 1.18

ITEM 7

Tim J. Browder
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San Marino, California
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Summary of Total Cost SC/SA

Total Major Equipment	12,071,600
Total Direct Material	5,887,700
Total Equipment & Mat'l	17,959,300
Total Field Costs	13,469,500
Total Constructed Cost	31,428,800
Home Office Costs - Payroll	713,000
Overhead	570,400
Contingency - 5% of Consis. Cost	1,511,400
Fee 5% of Constr C. + Contingency	1,650,000
Total Plant Cost	35,933,600

86% of DC/DA

COST OF SINGLE CONTACT PLANT 8/76 FOR 150,000 SCFM GAS FLOW TO REDUCE 2,2600 PPM SO_2. ADD 12% TO ABOVE FOR AVERAGE PURCHASING & CONSTRUCTION (2 YEARS × 6%/yr) = 12% (1.12 × 36MM)

1 yr delay with award add 6% more

Add $50,000 TO START UP & TRAIN OPERATORS

ESTIMATE ± 15%

Tim J. Browder
P. O. Box 8473
San Marino, California
91108, U. S. A.

Phelps Dodge
Douglas Arizona
SC/SA Sulfuric Acid Plant

1100	Towers	1,507,100
1300	Heat Exchgis	3,650,900
1400	Furnaces	139,500
1500	Pumps	304,400
1700	Cooling Tower	499,000
1800	Blowers	890,800
1900	Tanks	338,000
2500	Reactor	1,314,400
2800	Separation Eqpmt	3,103,700
2900	Stack	323,800
		12,071,600
	Total Major Eqpmt.	
4100	Concrete Work	689400
4200	Pipe, Ducts, etc.	2,339,300
4300	Structural	291,000
4400	Instruments	239,400
4500	Painting	123,300
4600	Electrical	1,192,500
4700	Insulation	277,700
4800	Paving & Fences	142,100
4900	Buildings	158,000
6200	Catalyst	435,000
	Total Direct Mat'l.	5,887,700
	Total Eqpmt & Mat'l.	17,959,300
	Total Field Costs - .75 × Eqpmt & Mat'l	13,469,500
	Total Constructed Cost	31,428,800

Tim J. Browder
P. O. Box 8473
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5c/5A Adjustments.

1100 Towers -	1,957,700
Less T-1106 Final Obs. Tower	450,600
Net Towers	1,507,100
1300 HT Exchgrs	5,296,800
Less HE-1304	283,900
1305	681,000
1306	681,000
Net HE	3,650,900
1500 Pumps	362,200
Less P-1505A	28,900
P-1505B	28,900
Net Pumps	304,400
1800 Blowers	932,800
Blowers - 5% Less 849,000 × .05 =	42,000
Net Blowers	890,800
1900 Tanks	472,400
Less TK-1905	134,400
Net Tanks	338,000
2800 Separation Equipment	3,225,200
Less S-2804	121,500
Net Separation Equipment	3,103,700
Total Major Equipment.	12,071,600

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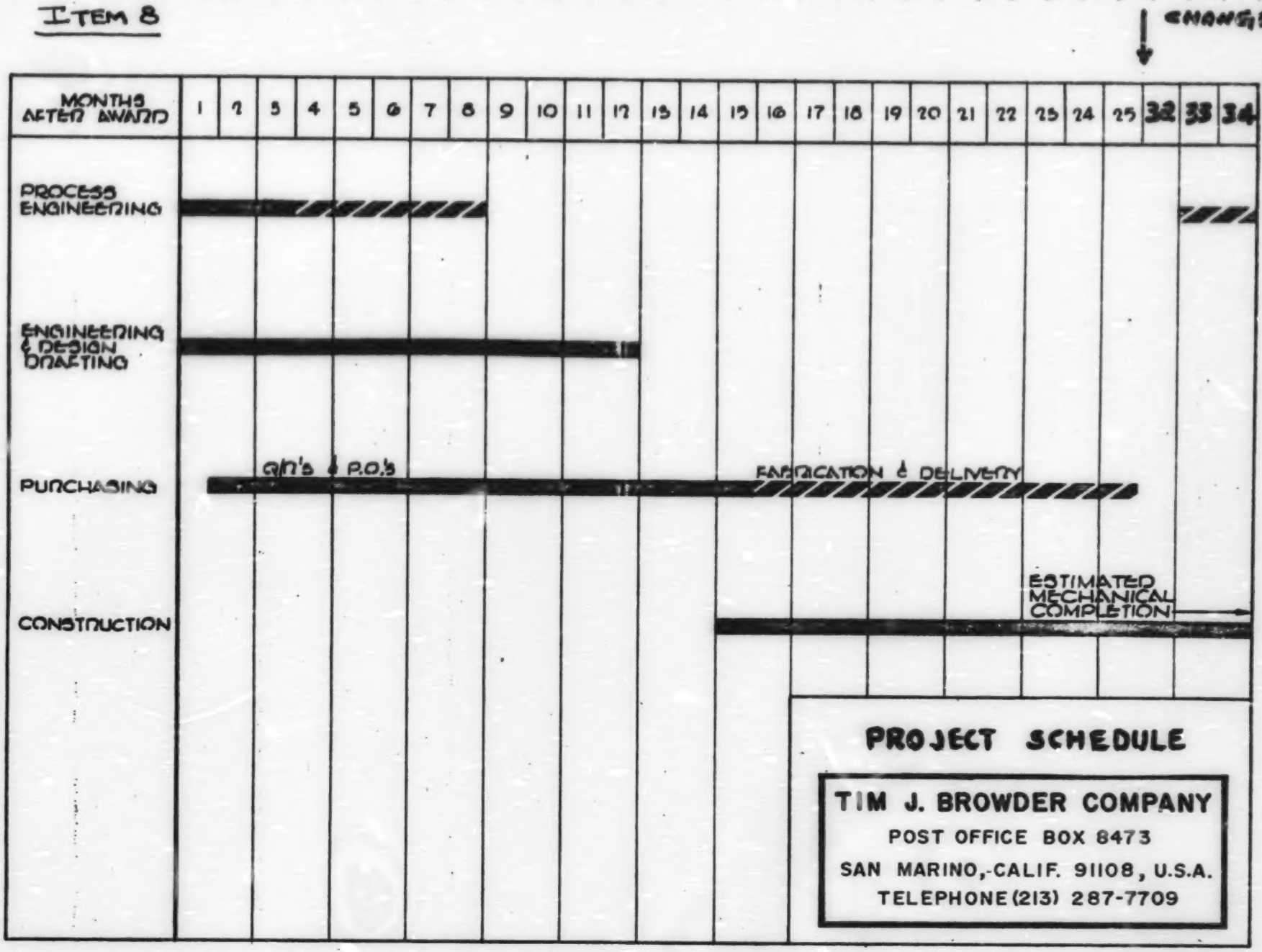
Sc/SA Adjustments

	Cu yds
4100 Foundations	2745
Less T-1106	127
Less HE-1304, 5 & 6	112
Less .03 × Main Blowers.	3
Less TK-1905	98
Net Cu yds.	2405
Concrete 2405 × #275/c.y.	661,400
Excavation 7000 × #4/cy	28,000
	689,400
4200 Pipe Ducts etc. .87 × 2,688,800	2,339,300
4300 Structural Steel .83 × 350,600	291,000
4400 Instruments 126/140 = .9 × 266,000	239,400
4500 Painting .9 × 137,000	123,300
4600 Electrical .95 × 1,255,300	1,192,500
4700 Insulation	330,900
Less 3 Heat Exchgrs	53,200
Net Insul.	277,700

ITEM 8


CHANGE
MONTHS AFTER AWARD
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 32 33 34
PROCESS ENGINEERING
ENGINEERING & DESIGN DRAFTING
PURCHASING
q/n's & P.O.'s
FABRICATION & DELIVERY
CONSTRUCTION
ESTIMATED MECHANICAL COMPLETION

PROJECT SCHEDULE

TIM J. BROWDER COMPANY

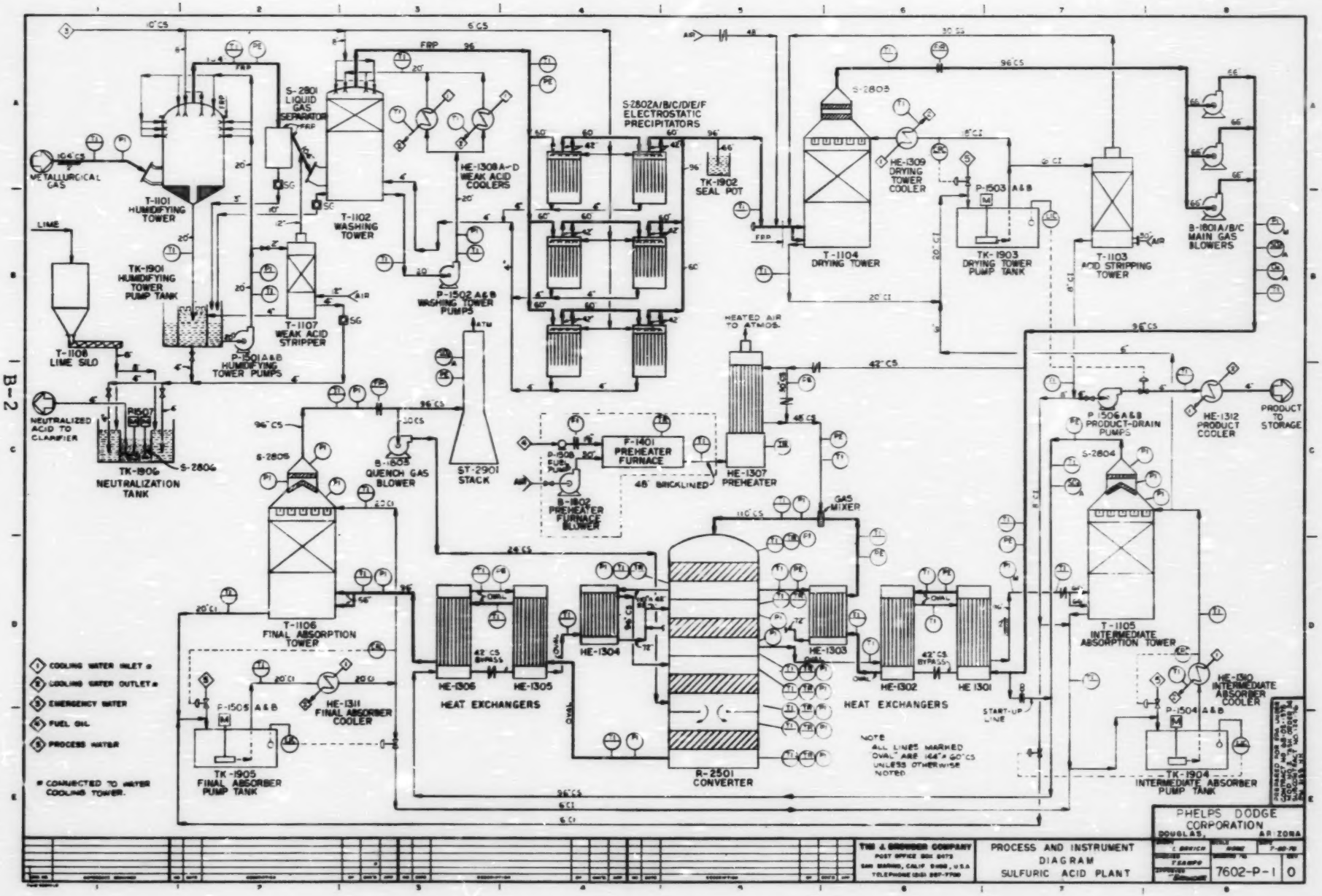
POST OFFICE BOX 8473

SAN MARINO,-CALIF. 91108, U.S.A.

TELEPHONE (213) 287-7709

APPENDIX B

SULFURIC ACID PLANT PLANS AND DIAGRAMS

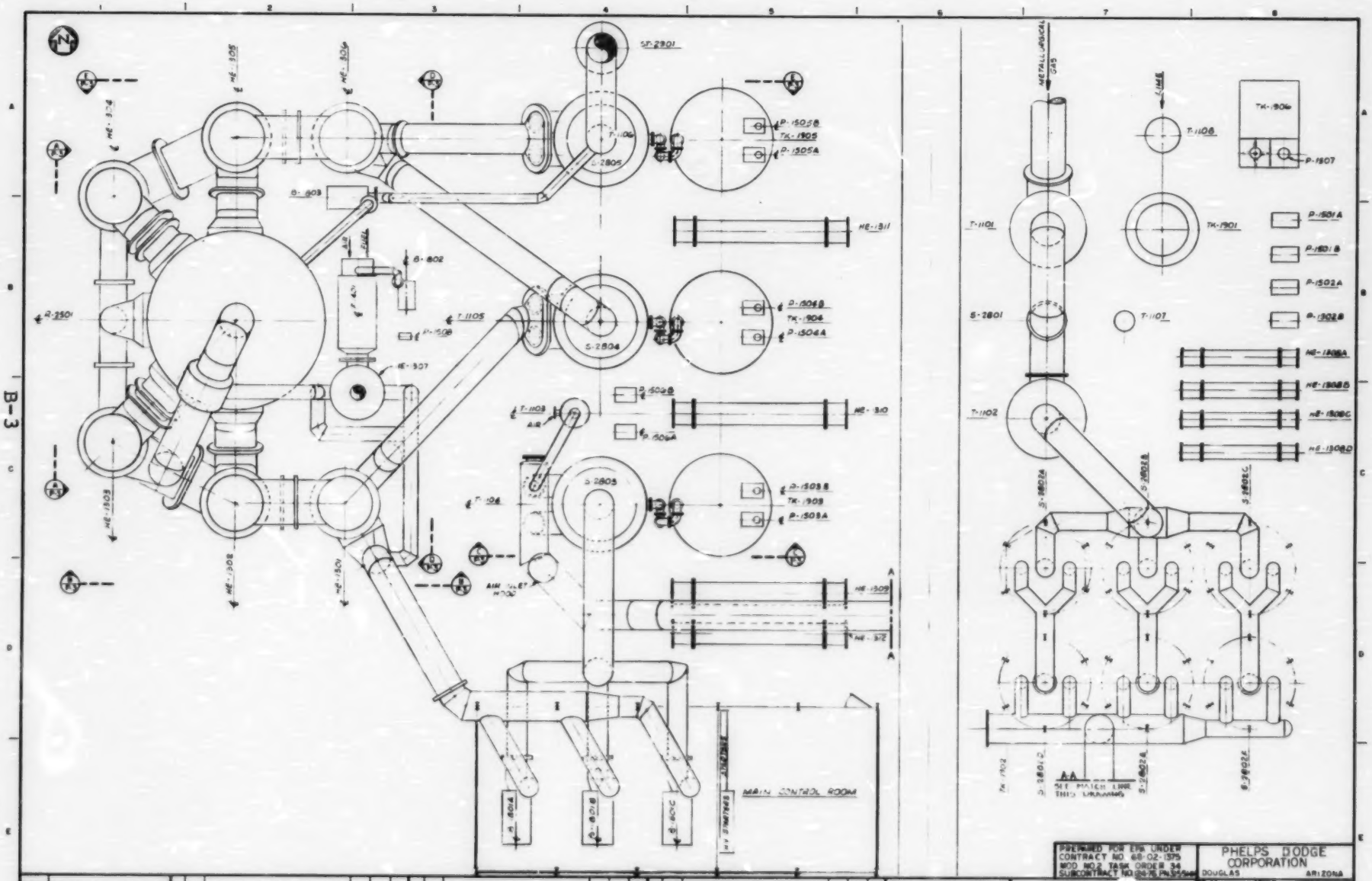


THE J. BRUDER COMPANY
POST OFFICE BOX 3473
SAN MATEO, CALIF. 94403, U.S.A.
TELEPHONE (415) 697-7700

PROCESS AND INSTRUMENT DIAGRAM
SULFURIC ACID PLANT

PHELPS DODGE CORPORATION
DOUGLAS, ARIZONA

7602-P-1 | 0



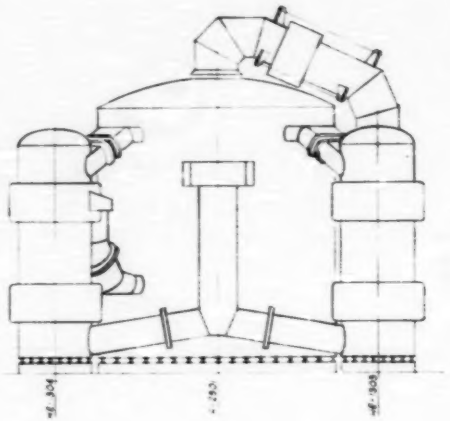
PREPARED FOR EPA UNDER CONTRACT NO. 68-02-1375 MOD. NO. 2 TASK ORDER # 34 SUBCONTRACT NO. 80-75-PN-5560

PHELPS DODGE CORPORATION
DOUGLAS ARIZONA

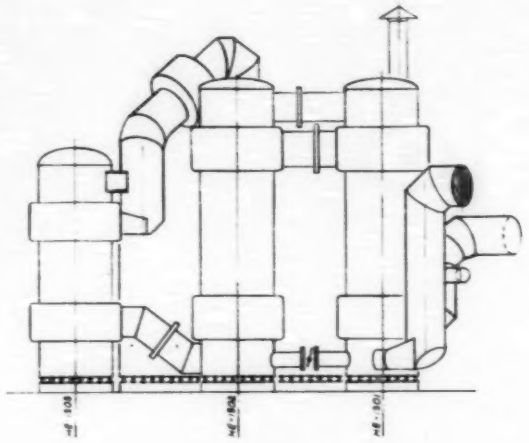
TIM A. CROUSER COMPANY
POST OFFICE BOX 8073
SAN MARINO, CALIF. 91108, U.S.A.
TELEPHONE (213) 287-7700

GENERAL ARRANGEMENT
PLOT PLAN
SULFURIC ACID PLANT

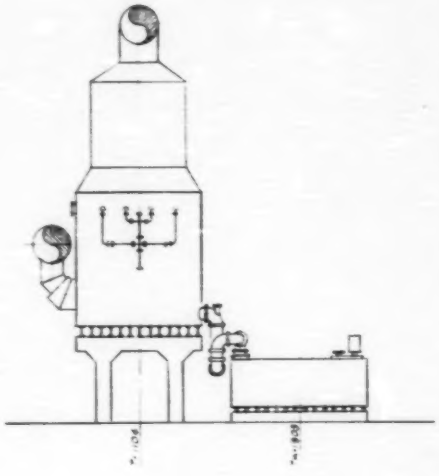
DRAWN	SCALE	DATE
J. ARRICK	1/16" = 1'-0"	7-28-76
ENGINEER: T. CROUSER	DRAWING NO. 7602-P-2	REV. 0



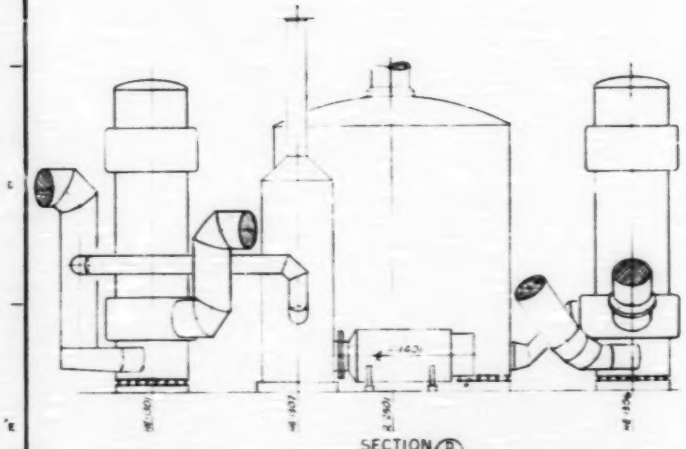
SECTION A P-2



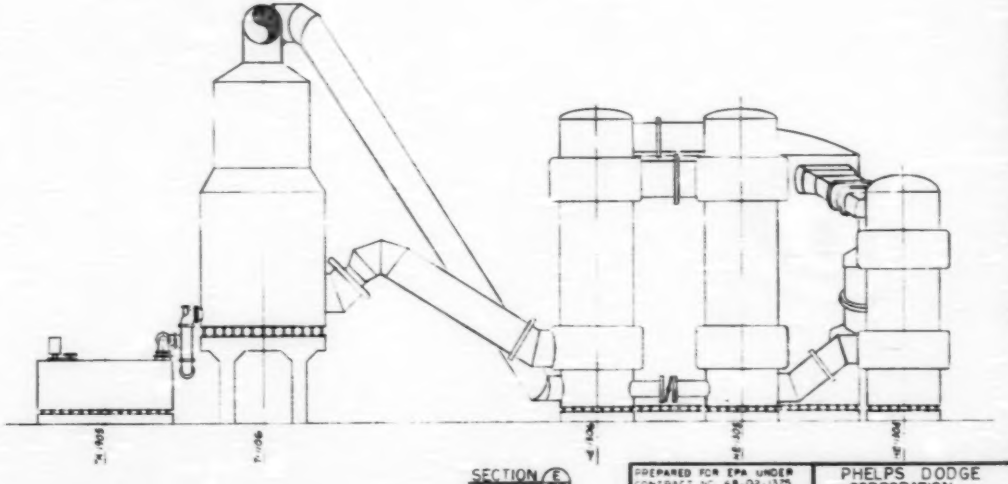
SECTION B P-2



SECTION C P-2



SECTION D P-2



SECTION E P-2

B-4

PREPARED FOR EPA UNDER CONTRACT NO. 68-02-1315 WORK NO. 2, TASK ORDER 34 SUBCONTRACT NO. 24-15,703-5000

PHELPS DODGE CORPORATION
DOUGLAS, ARIZONA

TIM J. BROWDER COMPANY
POST OFFICE BOX 0473
SAN MARINO, CALIF. 91108, U.S.A.
TELEPHONE (213) 287-7700

SECTIONS
SULFURIC ACID PLANT
(MAJOR EQUIPMENT ONLY)

DRAWN	SCALE	DATE
A. BROWN	3/32" = 1'-0"	7-28-82
CHECKED	DRAWING NO.	REV
T. SAMPO	7602-P-3	0
APPROVED		